EXTERNAL NITRIFICATION IN BIOLOGICAL NUTRIENT REMOVAL ACTIVATED SLUDGE SYSTEMS

by

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SYNOPSIS

Biological nutrient removal activated sludge (BNRAS) systems have become the preferred treatment system for advanced municipal wastewater treatment in South Africa. They have proven to be cost-effective systems that produce effluents of excellent quality that can be re-introduced to the receiving water bodies without a significant negative impact on the scarce surface water of South Africa. The widespread implementation of the BNRAS system has drawn attention to some weaknesses of the system, predominantly (i) the long sludge ages and resulting large biological reactor volumes required for nitrification, (ii) filamentous organism bulking of the sludge that develops in the system, (iii) treatment of the P rich waste sludge from the system and (iv) containment of the large mass of P in the sludge during a failure of the aeration in the system. In order to overcome the first two weaknesses of the system, it is proposed to separate the process of nitrification from the BNRAS mixed liquor and achieve nitrification externally to the BNRAS system.

External nitrification (EN) can be achieved in trickling filters (TFs) by promoting the growth of nitrifying bacteria on the fixed media, which will establish a permanent population of nitrifiers in the TF. With the slow growing nitrifiers effectively removed from the main BNRAS system and nitrification occurring externally in the TFs, the requirement to nitrify no longer governs the selection of the sludge age and aerobic mass fraction of the main BNRAS system. The sludge age can therefore be reduced from the usual 20 to 25 days to 8 to 10 days, increasing the capacity of an existing treatment works by about 50% or, alternatively, decreasing the required biological reactor volume per Ml wastewater treated by about ⅓. Furthermore, the unaerated mass fraction can be increased to 70% and above which results in a higher denitrification capacity. If a fraction of the additionally available unaerated mass fraction is added to the anaerobic zone, the BEPR performance will also improve. With an aerobic mass fraction of 30% or less, a better sludge settleability can be expected than is commonly observed in 'conventional' BNRAS systems with 40 to 60% aerobic mass fractions. This improvement in sludge settleability would further increase the wastewater treatment plant capacity.

EN can be implemented at watewater treatment plants (WWTPs) where old TFs have been extended with a BNRAS system. There are many such WWTPs, particularly in South Africa.

Often at these WWTPs, to retain the benefit of the old TFs, a portion of the influent wastewater is passed through the TFs and the effluent is either (i) discharged to the parallel BNRAS system for biological N and P removal, (ii) chemically treated to precipitate the P before discharging to the BNRAS system or the environment, or (iii) irrigated to land at the WWTP site. Discharging the TF effluents to the parallel BNRAS system causes a deterioration in effluent quality because the BNRAS system needs to remove more N and P with reduced influent organic material. Chemical treatment is expensive and increases the salinity of the water, and the irrigation of effluents to land is in the process of being carefully scrutinized by the Department of Water Affairs and Forestry because it conflicts directly with the policy of surface water conservation. If, instead of these three strategies, the nitrification process is transferred to the old TFs, BNR on the entire wastewater flow is possible. In this way the TFs assist the BNRAS system in the area of weakness, i.e. nitrification, rather than taking away from its strength, i.e. biological N and P removal with influent organic material.

Two investigations on laboratory scale ENBNRAS systems have been completed (Hu *et al.*, 1999 and Moodley *et al.*, 1999). The objectives of this third laboratory investigation into ENBNRAS system performance were to:

- Achieve consistent virtually complete EN and obtain steady state conditions for the BNR processes in the BNRAS system in order to confirm the results of the first two investigations for an ENBNRAS system operating at steady state.
- Evaluate anoxic P uptake under steady state conditions.
- Monitor the interaction between anoxic and aerobic P uptake, and to identify the conditions that trigger the shift between anoxic and aerobic P uptake and the effect of this on the overall BEPR performance.
- Compare the overall BNR performance of the ENBNRAS system with that of a 'conventional' BNRAS system (UCT configuration) with equivalent design and operating parameters receiving the identical watewaster as influent.

The laboratory scale ENBNRAS system of this investigation was operated for a total of 483 days and in 5 different configurations:

Configuration 1: 10 day sludge age, treating 20 l influent wastewater per day in 20 l total system volume with aerobic, anoxic and anaerobic mass fractions of 0.33, 0.42 and 0.25 respectively. (186 days, 13 sewage batches)

Configuration 2: Increased anoxic mass fraction of 0.55 and decreased aerobic mass fraction of 0.20. (98 days, 7 sewage batches)

Configuration 3: a-Recycle ratio of 2:1 with respect to influent flow removed (i.e. set to 0:1 with respect to influent flow). (137 days, 10 sewage batches)

Configuration 4: Sludge age decreased to 8 days and influent wastewater flow increased to 25 l/d.(49 days, 3 sewage batches)

Configuration 5: Sludge age decreased to 5 days. (13 days, 1 sewage batch)

A 'conventional' BNRAS system (UCT configuration) with equivalent design and operating parameters (10 day sludge age) was run in parallel with the ENBNRAS system of this investigation (Configurations 2 and 3) for 255 days and both systems were fed the same sewage that was prepared together. To monitor the performance of the laboratory scale systems, samples were drawn virtually daily from each of the reactors, internal settling tanks and the final effluent and analysed for TKN, FSA, NO_2/NO_3, COD and P.

System Performance for the 10 Day Sludge Age Configuration

- The overall average COD mass balance over the system was 80%. Of the 100% influent COD, on overall average, 94% COD removal was achieved (based on unfiltered COD samples).
- The overall average TSS and VSS concentrations in the ENBNRAS system were 1653 mgTSS/l and 1369 mgVSS/l respectively, giving an average VSS/TSS ratio of 0.83.
- The overall average oxygen utilisation rate (OUR) for Configuration 1 was 22.4 mgO/(l.hr) and that for Configurations 2 and 3 was 18.7 mgO/(l.hr). The OUR for Configuration 1 was higher, because of its higher aerobic mass fraction of 0.33 compared to that of 0.20 for Configurations 2 and 3.
- On overall average, 89% of the FSA flowing into the EN system was nitrified to nitrate, while 87% of the system nitrification occurred externally (i.e. in the EN system as opposed to in the main BNRAS system). This indicates that the EN system nitrifies only about 90% of the FSA passed through it, i.e. 100% nitrification does not occur. Furthermore, nitrification cannot be totally excluded from the aerobic reactor of the main BNRAS, and around 10 to 13% of the ENBNRAS system nitrification remains in the aerobic reactor of the main BNRAS system.
- The overall average denitrification potential for Configurations 1, 2 and 3 was 22.0, 19.0

and 31.1 mgN/l influent respectively. The pre-anoxic reactor denitrification potential was 4.5 mgN/l for Configurations 1, 2 and 3. A toxic sewage batch adversely affected the denitrification potential of the ENBNRAS system, resulting in the very low average denitrification potentials for Configurations 1 and 2. This toxic sewage batch had a more pronounced effect on the average denitrification potential of Configuration 2 causing an even lower average denitrification potential than for Configuration 1, even though Configuration 2 had the larger anoxic mass fraction.

- The overall average N mass balance over the system was 88%. The ENBNRAS system final effluent contained 11.9 mgN/l total N (TN) on average overall, of which 5.2 mgN/l was TKN, 5.8 mgN/l nitrate and 0.9 mgN/l nitrite. Hence, the overall average TKN removal of the ENBNRAS system was 94% and the TN removal was 86%.
- The overall average P release was 17.3 mgP/l influent in the anaerobic reactor and internal settler A. An additional 4.5 mgP/l was released in the EN system, but it is unlikely to be coupled with SCFA uptake by the PAOs and hence its benefit to the BEPR is questionable. This P release was not included in the BEPR calculations, but it represents P that needed to be taken up again in the main anoxic and aerobic reactors. The overall average P uptake was 33.1 mgP/l influent, with 62 and 38% occurring in the main anoxic and main aerobic reactors respectively.
- The overall average P removal of the ENBNRAS system was 9.8 mgP/l influent with significant anoxic P uptake. This was about 40% less P removal than would be expected from a similar 'conventional' BNRAS system with predominantly aerobic P uptake.
- The overall average DSVI of the ENBNRAS system sludge was 108 ml/g. However, after the system recovered from the toxic sewage batch, the DSVI stabilised at around 90 ml/g, and the higher overall average DSVI was due to the poor sludge settleability during the period where the system was affected by the toxic sewage batch.
- The main filamentous organisms identified in the ENBNRAS system were *M.parvicella*, type 1851, type 0092 and *H.hydrossis*.

System performance for the 8 and 5 Day Sludge Age Configurations (4 and 5)

- The overall average COD mass balances for the 8 and 5 day sludge age configurations were 79 and 92% respectively and the overall average COD removals (based on unfiltered COD samples) 93 and 90% respectively.

- On overall average for the 8 and 5 day sludge age configurations, 88 and 96% of the FSA flowing into the EN system was nitrified and 93 and 95% of the total system nitrification occurred externally (i.e. in the EN system) respectively.
- The overall average denitrification potential of the main anoxic reactor was 46 and 34 mgN/l influent for the 8 and 5 day sludge age configurations respectively.
- The overall average N mass balances attained for the 8 and 5 day sludge age configurations were 85 and 95% respectively. The overall average TKN removal was 94 and 92% and the TN removal was 92 and 76% respectively. The low TN removal for the 5 day sludge age configuration was due to the combination of a high influent TKN/COD ratio and the lower denitrification potential of the main anoxic reactor.
- The overall average P removal for the 8 and 5 day sludge age configurations was 14.0 and 8.6 mgP/l influent respectively. The % P uptake occurring in the anoxic reactor was 47% and 58% respectively. The lower P removal for the 5 day sludge age configuration was due to the high nitrate concentration recycled to the anaerobic reactor, resulting in low P release and hence low P removal.
- The overall average DSVI for the 8 and 5 day sludge age configurations was 90 and 93 ml/g respectively.

Comparison of the ENBNRAS System with a 'Conventional' BNRAS System (UCT Configuration)

- The overall average COD mass balance achieved for the UCT and ENBNRAS systems was 78 and 77% respectively. The overall average COD removal (based on unfiltered COD samples) was 93 and 94% respectively.
- The overall average total oxygen demand of the UCT and ENBNRAS systems was 7625 and 1798 mgO/d respectively. By nitrifying externally, the ENBNRAS system requires an average of 76% less oxygen per day than the UCT system.
- The overall average N mass balance for the UCT and ENBNRAS systems was 86 and 87% respectively. The overall average final effluent TN of the UCT system was 16.8 mgN/l, of which 4.0 mgN/l was TKN (of which 1.8 mgN/l was FSA) and 12.8 mgN/l was NO_X. For the ENBNRAS system, the overall average final effluent TN was 9.8 mgN/l, of which 5.2 mgN/l was TKN (of which 3.5 mgN/l was FSA) and 4.6 mgN/l was NO_X.
- The overall average P release for the UCT and ENBNRAS systems was 21.3 and 18.3

mgP/l influent respectively. On overall average, 34.0 and 32.8 mgP/l influent P uptake occurred in the UCT and ENBNRAS systems respectively. Of the system P uptake, 9.8% P uptake occurred in the anoxic reactor for the UCT system while 60% anoxic P uptake occurred in the ENBNRAS system.

- The overall average P removal for the UCT and ENBNRAS systems was 12.7 and 9.8 mgP/l influent respectively.
- The overall average DSVI for the UCT and ENBNRAS system was 138 ml/g and 103 ml/g respectively.

Closure

The investigations on laboratory scale ENBNRAS systems by Hu *et al.* (1999), Moodley *et al.* (1999) and this investigation show that BNRAS system intensification by separating the process of nitrification from the main BNRAS system and effecting nitrification externally is possible in practice. The EN systems implemented in the three laboratory scale ENBNRAS system investigations nitrified between about 85 and 90% of the FSA flowing into them, indicating that they do not nitrify 100% of the FSA passed through them. In addition, it seems that it is not possible to obtain 100% of the ENBNRAS system nitrification externally. Up to 90% of the total system nitrification can occur externally, but residual nitrification (of the FSA not nitrified in the EN system and the FSA in the sludge bypass) will occur in the main aerobic reactor.

The laboratory scale ENBNRAS systems removed >90% of the influent carbonaceous material utilising on average about 76% less oxygen than an equivalent 'conventional' BNRAS system. The ENBNRAS systems have shown excellent TKN and very good TN removals (TKN removals >90%, TN removals >80%), and it has been shown that the ENBNRAS systems are capable of producing effluents with TN concentrations of <10 mgN/l for influent wastewaters with TKN/COD ratios of up to between 0.13 and 0.14.

The BEPR occurring in the BNRAS systems is undoubtably anoxic/aerobic P uptake BEPR with the anoxic reactor effecting up to 60 - 70% of the total system P uptake. The magnitude of the anoxic uptake BEPR is dependant on the nitrate load on the main anoxic reactor. If the nitrate load is equal to or below the denitrification potential of the main anoxic reactor, the % anoxic P uptake will decrease and the % aerobic P uptake will increase provided the aerobic mass fraction is sufficiently large to complete the P uptake process. Conversely, when the nitrate load on the main anoxic reactor is greater than the denitrification potential of the main anoxic reactor, the % anoxic P uptake will increase, and the % aerobic P uptake will decrease. As the P uptake shifts from predominantly anoxic P uptake to increased aerobic P uptake, the total P removal seems to increase. It appears that a steady state in terms of anoxic P uptake is not reached, because the P uptake shifts from anoxic P uptake to aerobic P uptake and vice versa, as the nitrate load on the main anoxic reactor increases or decreases. It would therefore not be advisable to implement aerobic mass fractions much smaller than 0.20, even though it is theoretically possible to do so, it would be detrimental to the overall BEPR. The P removal in the ENBNRAS systems is about ⅓ less than in a similar 'conventional' BNRAS system with predominantly aerobic uptake BEPR. The ENBNRAS systems produce sludges that settle very well (from about 70 to 110 ml/g) and it seems that they are not affected to the same extent as 'conventional' BNRAS systems are by high nitrate concentrations flowing from the main anoxic reactor, as stated in the AA filament bulking hypothesis of Casey *et al.* (1994).

It has further been demonstrated that the ENBNRAS systems perform full and uncompromised BNR for short sludge ages down to about 5 days. Conversely the influent flow can be doubled to an existing system without a negative impact on the BNR, provided the system does not fail hydraulically due to the increased influent sewage flow. Sludge ages below 10 days have an added advantage in that N and P removals increase per mass of organic load (Wentzel *et al.*, 1990) as the sludge age is reduced.

The comparison of the laboratory scale ENBNRAS system of this investigation with a laboratory scale 'conventional' BNRAS system (UCT configuration) demonstrated that the carbonaceous material removal performance of both systems was effectively equal. The TN removal performance of the ENBNRAS system was superior to that of the UCT system, in that the ENBNRAS system produced effluents with half the TN concentrations of the UCT system final effluent. The results of the ENBNRAS system showed further that the ENBNRAS is capable of producing effluents with TN concentrations of <10 mgN/l, while this is not the case for the UCT system. Furthermore, the ENBNRAS system is able to perform total denitrification in the main anoxic reactor, while this was not possible for the UCT system because of the limitation imposed by the a-recycle.

The UCT system showed higher BEPR than the ENBNRAS system. With predominantly aerobic P uptake BEPR occurring in the UCT system, it removed on average 3 mgP/l influent more P than the ENBNRAS system. With the anoxic/aerobic P uptake BEPR that occurred in the ENBNRAS system, about 23% less P was removed than in the UCT system.

The ENBNRAS system produced a sludge with a DSVI of between 90 and 100 ml/g, while the DSVI of the UCT system fluctuated between 80 and 200 ml/g. This difference becomes particularly apparent when very high nitrate concentrations flow from the anoxic reactor of the UCT system. The UCT systems DSVI responded to the high nitrate concentrations flowing from the anoxic reactor with a sharp increase in DSVI from about 100 ml/g to about 200 ml/g, while the ENBNRAS system sludge DSVI increased from around 90 ml/g to just over 100 ml/g at significant nitrate concentrations in the outflow of the main anoxic reactor. The UCT system is hence much more sensitive to AA filament bulking with significant nitrate concentrations in the outflow of the anoxic reactor than the ENBNRAS system. This is because the aerobic mass fraction of the UCT system was 0.50 and within the range of applicability of the AA filament bulking hypothesis of Casey *et al.* (1994), whereas the aerobic mass fraction of the ENBNRAS system was 0.20 which falls outside the range of applicability of the hypothesis.

The investigations on the three laboratory scale ENBNRAS systems provide a comprehensive framework for understanding of ENBNRAS system operation and performance, and further laboratory investigations would not provide additional knowledge and understanding. The next step would be to begin full scale trials of an ENBNRAS system. To begin with, a full scale trickling filter would have to be converted into a nitrifying trickling filter to ascertain its performance as a nitrifying trickling filter at full scale. Once it has been proven that existing full scale trickling filters can successfully be converted to nitrifying trickling filters and their capacity determined, the trickling filters can be integrated into a BNRAS system in an ENBNRAS system configuration to obtain BNR on the full influent wastewater flow.

Initially it was thought that the savings in capital cost brought about by an increased capacity or smaller biological reactors, reduced oxygen demand and better settling sludge would make the ENBNRAS system an attractive and viable alternative as a full scale plant. The economic evaluation of Little *et al.* (2000) however indicates that this may not be the case. While the ENBNRAS system alternative does provide a saving in construction costs of about 30% when compared to a 'conventional' BNRAS system, the operating costs in the long run overshadow this saving. The operating costs of a sewage treatment works, whether ENBNRAS or 'conventional' BNRAS system, account for the bulk of the net present value (NPV) which are about the same for both configurations. While significant savings in operation costs are made from the very low oxygen demand, the increased sludge production at the shorter sludge ages and the associated increase in sludge treatment, transport and disposal costs reduce these savings. While the total NPV (capital, operation and maintenance) for the ENBNRAS system option is 5 to 10% lower than that of a 'conventional' BNRAS system, this difference may not be large enough for a definite choice of the ENBNRAS system over the 'conventional' BNR system. However, the most significant advantage is that the ENBNRAS system offers biological N and P removal for the full wastewater flow without increase in existing process units. If the Department of Water Affairs and Forestry implement the proposed new effluent quality standards promulgated under the National Water Act of 1998, the ENBNRAS will provide a feasible and economical plant upgrade option. Thus, while the ENBNRAS system does not provide a large enough saving in monetary terms to make it an attractive alternative, the new effluent quality standards may favour the ENBNRAS system. The ENBNRAS system is capable of producing effluents with a quality that are within the new effluent quality standards, especially with regards to nitrogen. The proposed new effluent quality standards rather than economics may well be the driving force that will see the ENBNRAS system implemented at full scale.

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SYMBOL	DESCRIPTION
AS	Activated sludge
AVSS	Active volatile suspended solids
BEPR	Biological excess phosphorus removal
b_{gT}	Specific endogenous mass loss rate constant for PAOs (temperature dependent)
b_{hT}	Specific endogenous mass loss rate constant for OHOs (temperature dependent)
BNR	Biological nutrient removal
BNRAS	Biological nutrient removal activated sludge
COD	Chemical oxygen demand
DO	Dissolved oxygen
D_p	Denitrification potential
DSVI	Dilute sludge volume index
DWAF	Department of Water Affairs and Forestry
EN	External nitrification
ENBNRAS	External nitrification biological nutrient removal activated sludge
f	Unbiodegradable fraction of organisms
f_{cv}	COD/VSS ratio of volatile solids
$f_{ep,g}$	Fraction of PAOs that is unbiodegradable particulate residue
$f_{s,up}$	Unbiodegradable particulate fraction of the influent COD
$f_{s,us}$	Unbiodegradable soluble fraction of the influent COD
FSA	Free and saline ammonia
f_{x1}	Anoxic mass fraction
f_{xa}	Anaerobic mass fraction
$f_{xbg,p}$	Fractional P content of PAO active mass
$f_{xbh,p}$	Fractional P content of OHO active mass
$f_{xeg,p}$	Fractional P content of PAO endogenous mass

$f_{xeh,p}$	Fractional P content of OHO endogenous mass
$f_{xi,p}$	Fractional P content of inert mass
IAND	Intermittently aerated nitrification / denitrification
ISS	Inert suspended solids
K_2'	Specific denitrification rate for the OHOs (disregarding the PAOs) on SBCOD
$K_2''_{OHO}$	Specific denitrification rate for the OHOs on SBCOD
$K_2''_{PAO}$	Specific denitrification rate for the PAOs
K_{ct}	First order rate constant for the conversion of RBCOD to SCFA
μ_{hm20}	Maximum specific growth rate of the OHOs (at 20° C)
μ_{nm20}	Maximum specific growth rate of the PAOs (at 20° C)
MS_{seq}	Mass of RBCOD sequestered
$MX_{b,g}$	PAO active mass
$MX_{b,h}$	OHO active mass
$MX_{e,g}$	PAO endogenous mass
$MX_{e,h}$	OHO endogenous mass
MX_i	Inert mass
MX_v	Volatile solids mass
N	Nitrogen
NDBEPR	Nitrification / denitrification biological excess phosphorus removal
NO_X	Nitrite and Nitrate
NPV	Net present value
OHO	Ordinary heterotrophic organism
OUR	Oxygen utilisation rate
P	Phosphorus
PAO	Polyphosphate accumulating organism
PHB	Poly-β-hydroxybutyrate
Q_i	Influent flow
RBCOD	Readily biodegradable chemical oxygen demand
R_S	Sludge age
S_{bi}	Influent biodegradable COD concentration

S_{bsi}	Influent biodegradable soluble COD (RBCOD) concentration
SCFA	Short chain fatty acids
SST	Secondary settling tank
S_{te}	Total COD concentration in the effluent
S_{ti}	Total COD concentration in the influent
S_{usi}	Unbiodegradable soluble COD fraction
SVI	Sludge volume index
TF	Trickling filter
TKN	Total Kjeldahl nitrogen
TSS	Total suspended solids
UCT	University of Cape Town
VSS	Volatile suspended solids
WWTP	Wastewater treatment plant
X_a	Active organism concentration
Y_g	Specific yield constant for the PAOs
Y_h	Specific yield constant for the OHOs

CHAPTER 1

INTRODUCTION

In South Africa (SA) today the most common municipal wastewater technology practised is that of the activated sludge (AS) system, and more specifically biological nutrient removal (BNR) in this system, has become the preferred treatment system. The BNRAS system is now the system of choice for new sewage treatment plants in SA for the following reason: A BNRAS system, in any of its guises, provides a cost-effective treatment process that produces an effluent of excellent quality, which does not exacerbate the problems of increasing salinity and eutrophication in the receiving water bodies. This is of particular importance in the inland regions of SA, because salination and eutrophication pose a serious threat to surface water quality. Since surface water in most regions of SA is scarce, and many areas experience severe water shortages, the conservation of the available surface water and its quality is crucial. The BNRAS technology has advanced so far to date, that appropriately designed full scale BNRAS systems are capable of reducing the chemical oxygen demand (COD), the nitrogen (N) and phosphorus (P) content and the total suspended solids (TSS) of the influent wastewater to such low levels, that the effluents have very little effect on the receiving water bodies. However, the implementation of BNRAS systems has drawn attention to some weaknesses of the system, predominantly (i) the long sludge ages and resulting large biological reactor volumes required for nitrification, (ii) filamentous organism bulking of the sludge that develops in the system, (iii) treatment of the P rich waste sludge from the system and (iv) containment of the large mass of P in the sludge during aeration breakdown in the system. This thesis considers the first two of these four problems.

In BNRAS systems that are required to remove N, nitrification is a prerequisite. The autotrophic bacteria that mediate nitrification are relatively slow growing with a maximum specific growth rate at 20° C (μ_{nm20}) of around 0.45/d, compared to the maximum specific growth rate of the heterotrophic bacteria at 20° C (μ_{Hm20}) of around 3.5/d. It is therefore the requirement to nitrify that determines the selection of the sludge age, and since nitrification occurs under aerobic[1] conditions it also governs the selection of the aerobic mass fraction. A further prerequisite for N

[1]The term aerobic describes a zone with a high dissolved oxygen (DO) content.

removal is that a part of the sludge needs to be anoxic[2] for denitrification to occur. If P removal is required in addition to the N removal, a further part of the sludge needs to be anaerobic[3] for biological excess P removal (BEPR) to be stimulated. This leads to a situation in the design of N and P removal plants where the need for high unaerated mass fractions required for N and P removal conflicts with the need for a sufficiently high aerated mass fraction that will ensure complete nitrification. For an unaerated mass fraction of between 50 and 60% the resulting aerated mass fraction is less than 50%. To ensure that complete nitrification occurs at the lowest expected temperature with an aerobic mass fraction of less than 50%, the sludge age selected must be between 20 and 25 days. Sludge ages of this magnitude result in very large biological reactor volumes per Ml wastewater treated.

With regard to filamentous bulking, Casey *et al.* (1994) report that the two main causes for AA filament proliferation, which causes sludges to bulk, are:

(i) An aerobic mass fraction between 25 and 75%, and

(ii) incomplete denitrification in the anoxic zone that precedes the aerobic zone.

BNRAS systems that are designed for both N and P removal inevitably have an aerobic mass fraction of between 40 and 50%, and this is in the range in which Casey *et al.* report a high incidence of AA filament proliferation resulting in bulking sludges (see Chapter 2, Section 2.3.4 for further details).

In order to overcome these two problems of conventional BNRAS systems, it is proposed that if the process of nitrification can be separated from the BNRAS mixed liquor, i.e. that if nitrification can be achieved externally to the BNRAS system, these two inherent weaknesses of the BNRAS system can be avoided. In essence, by virtue of achieving nitrification externally, a BNRAS system is significantly intensified, because:

(i) The sludge age can be reduced from the usual 20 to 25 days to one of between 8 to 10 days since it is no longer governed by nitrification, but rather by the denitrification and BEPR processes. This reduction in sludge age increases the treatment capacity of an existing treatment works by about 50% or, alternatively, decreases the required biological reactor volume per Ml wastewater treated by about ⅓, without impacting negatively on

[2]The term anoxic refers to a zone where nitrate/nitrite are present but no DO is present.
[3]The term anaerobic refers to a zone where neither nitrate/nitrite nor DO are present, and where none of those compounds enter the zone.

either biological N or P removal.

(ii) The unaerated mass fraction can be increased to 70% and above without losing the benefit of nitrification, since this is now effected externally. This increase in the unaerated mass fraction results in a higher denitrification potential and complete denitrification can be achieved, depending on the TKN/COD ratio of the influent wastewater. If a fraction of the additionally available unaerated mass fraction is added to the anaerobic zone, the BEPR performance will also improve.

(iii) The oxygen demand of the BNRAS system decreases by about 40 to 60%, as the nitrifiers are now located externally, and only the carbonaceous oxygen demand remains in the main system itself. The nitrate that is generated externally and returned to the BNRAS system reduces the carbonaceous oxygen demand.

External nitrification (EN) can be achieved in trickling filters (TFs) by promoting the growth of nitrifying bacteria on the fixed media, which will establish a permanent population of nitrifiers in the TF. This population will not be subjected to any unaerated zones, and it is no longer dependant on a sludge age since it is permanently resident on a fixed media. Such tertiary nitrifying TFs are fairly common in the USA (Lutz *et al.*, 1990) and high removals of ammonia have been achieved in these tertiary nitrifying TFs (Parker *et al.*, 1989, 1995, 1996). The fact that EN can be achieved by means of TFs signifies that EN may hold some potential in the context of South African wastewater treatment.

Many wastewater treatment plants (WWTPs) in SA incorporate old TFs that have been extended with a BNRAS system. The local authorities that operate these plants usually retain the benefit of the old TFs by passing a portion of the influent flow through them, as shown in Fig. 1.1. The TFs used in such a configuration will mainly perform carbonaceous material removal and possibly nitrification to a certain extent. This results in an effluent with a very low COD concentration and virtually unchanged N and P content. This TF effluent with its effectively increased TKN/COD and P/COD ratios cannot be discharged with the BNRAS system effluent and as Fig. 1.1 below indicates, the TF effluents are:

(1) Irrigated to land on site of the WWTP.
The practice of irrigating WWTP effluents to land is in the process of being carefully

scrutinized by the Department of Water Affairs and Forestry because this conflicts directly with the policy of surface water conservation.

(2) Treated chemically to precipitate P and either discharged with the BNRAS system effluent or returned to the BNRAS system for biological N removal.

Chemical treatment is not only costly, but it also increases the salinity and reduces the alkalinity of the wastewater. Since only the P is removed, the effective TKN/COD of the effluent remains unchanged.

(3) Discharged to the influent of the BNRAS system for biological N and P removal.

The addition of the TF effluent to the BNRAS system influent increases the TKN/COD and P/COD ratio of the BNRAS system influent. In effect the BNRAS system is deprived of a portion of the COD needed to perform biological N and P removal, and it is burdened with additional N and P in the influent. This leads to a marked deterioration in the quality of the BNRAS system effluent.

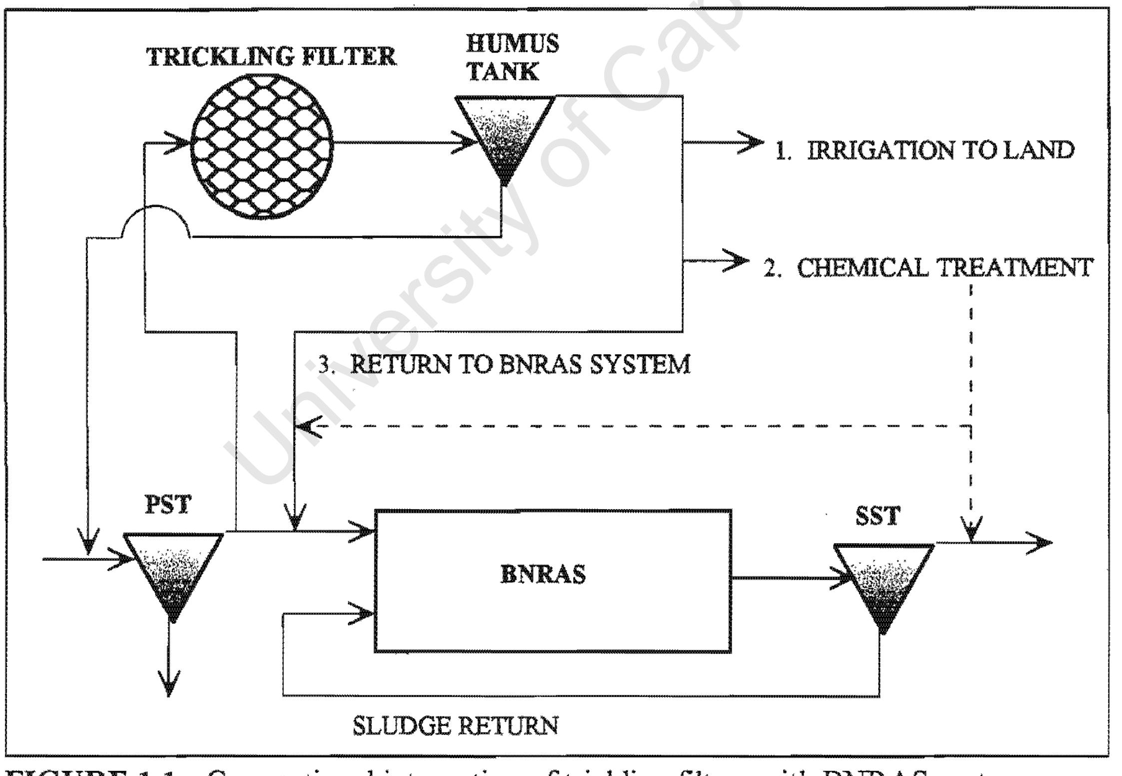

FIGURE 1.1 - Conventional integration of trickling filters with BNRAS systems.

Since options (1) and (2) are not practical from a South African point of view, it is option (3) that is frequently implemented by the local authorities. However, by implementing option (3) the BNRAS system performance is negatively impacted by virtue of depriving the BNRAS system of the carbon source it requires to remove N and P, while at the same time increasing the concentrations of N and P in the influent. If, instead of the options described above, EN is implemented by transferring nitrification to the TFs, the entire influent wastewater can be discharged to the BNRAS system without compromising on effluent quality. In fact, such a reconfigured system will allow biological nutrient removal to be achieved on the full wastewater flow in the same system units. Fig. 1.2 shows the re-configuration of the plant shown in Fig. 1.1 to accommodate the concept of EN.

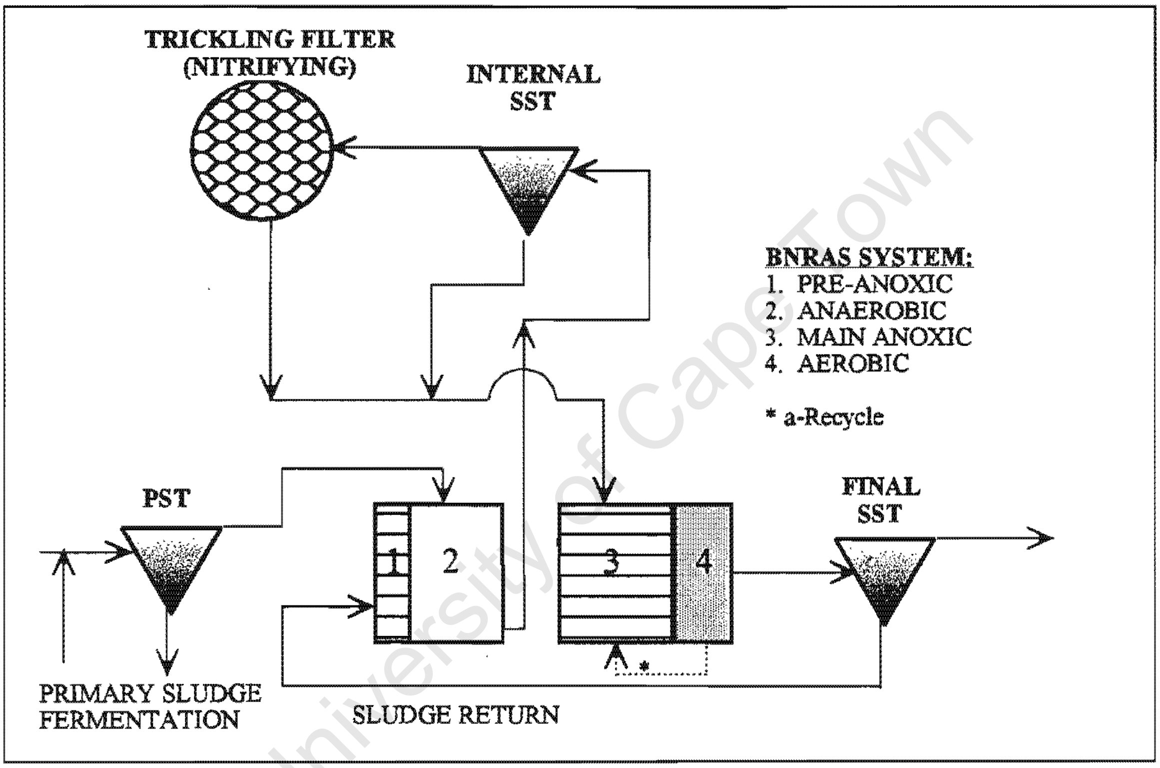

FIGURE 1.2 - Proposed re-configuration to an external nitrification system: Nitrification is achieved externally on nitrifying trickling filters.

The influent wastewater enters the BNRAS system after an optional primary sludge fermentation process. Fermentation of the primary sludge is not mandatory, but it improves the BEPR performance by increasing the short chain fatty acid concentration of the influent wastewater (Lilley *et al.*, 1991). The mixed liquor is taken from the end of the anaerobic zone of the BNRAS system and passed through the TF humus tank, which is upgraded into an internal secondary settling tank (SST). The overflow is passed through the nitrifying TF for nitrification, and the nitrified TF effluent is returned to the beginning of the anoxic zone of the BNRAS system for denitrification. The BNRAS system sludge mass that is removed in the internal SST bypasses the nitrifying TF and is returned directly to the beginning of the anoxic zone of the BNRAS system - hence EN has been achieved. The BNRAS system is modified to accommodate mixed liquor abstraction at the end of the anaerobic zone as well as the return of the sludge and nitrified supernatant to the beginning of the anoxic zone. A small pre-anoxic zone is created at the head of the BNRAS system, and this zone receives the underflow from the final SSTs. This pre-anoxic zone is introduced for the following reason: It is not possible to totally exclude the nitrifiers from the BNRAS system sludge, and nitrification of the ammonia from the underflow of the internal SST and of any other residual ammonia not nitrified in the TFs, may occur in the aerobic zone. Since the aerobic zone precedes the final SST, this nitrate will be recycled directly into the anaerobic zone through the sludge return, and to avoid the negative effect of this nitrate on the BEPR, the sludge return is routed into the pre-anoxic zone where the nitrate can be denitrified.

The main benefits of the EN configuration are:

(i) All of the influent wastewater is treated in the BNRAS system without a deterioration in effluent quality. The Department of Water Affairs and Forestry is in the process of implementing stricter water quality discharge standards (Wates, Meiring and Barnard, 1999 - see Chapter 2, Section 2.3.2 for further details) which will not be achieved by the system described in Figure 1.1 option (3) above. However, the ENBNRAS shown in Figure 1.2 has the potential to meet the proposed new discharge standards.

(ii) The oxygen demand in the aerobic reactor of the BNRAS system is reduced by about 40 to 60% because nitrification no longer takes place in the aerobic zone of the BNRAS system. The nitrification oxygen demand is obtained at no cost on the TFs so that in effect the treatment capacity of the BNRAS system is increased without the need for an increase in the existing aeration capacity in the BNRAS system.

(iii) With nitrification no longer playing a role in the BNRAS system, the unaerated mass fraction can be increased as explained above. If the unaerated mass fraction is increased by enlarging the anoxic zone(s), complete denitrification may be possible, depending on the TKN/COD ratio of the influent wastewater, and/or if the anaerobic fraction is also increased, BEPR performance will also improve. If the aerobic mass fraction is reduced to below 30%, a marked improvement in the sludge settleability can also be expected (see Chapter 2, Section 2.3.4).

Two investigations on laboratory scale ENBNRAS systems have been conducted in the Wastewater Research Laboratory of the University of Cape Town (Hu *et al.*, 1999 and Moodley *et al.*, 1999 - see Chapter 2, Section 2.3.3 for further details). The investigation of Hu *et al.* (1999) focussed mainly on establishing a permanent population of nitrifiers in a laboratory scale stone column, integrating the stone column into a BNRAS system to form a ENBNRAS system and investigating the following on that ENBNRAS system:

(i) Does the ENBNRAS system produce a sludge that settles well consistently?

(ii) If anoxic P uptake BEPR is to be exploited, is it as good as aerobic uptake BEPR?

(iii) What are the factors that promote anoxic P uptake BEPR?

The investigation of Moodley *et al.* (1999) concentrated on the following objectives:

(i) To double the volume of wastewater treated and thereby testing the claim of system intensification due to shorter sludge ages and improved sludge settleability.

(ii) Promote conditions to achieve aerobic P uptake BEPR.

(iii) Increase the aerobic mass fraction to quantify its effect on anoxic P uptake, and

(iv) study the effect this increase in aerobic mass fraction has on the sludge settleability.

When BNRAS systems operate with low aerobic mass fractions (~20%), a shift in the BEPR process has been noted. Whereas P uptake usually occurs predominantly under aerobic conditions, significant (>40%) anoxic P uptake can take place if the anoxic mass fraction is large enough and the nitrate load on the anoxic reactor is sufficiently high. Ekama and Wentzel (1999) noted in conventional and external nitrification BNRAS systems, that when significant anoxic P uptake takes place, the BEPR performance is reduced, to as low as ⅔ of that when the P uptake is predominantly (>95%) aerobic. This phenomenon is reviewed in greater detail in Chapter 2, Section 2.1 and is an important aspect of the ENBNRAS system to investigate.

The primary objectives of this investigation on a third laboratory scale ENBNRAS system are as follows:

(i) To achieve consistent virtually complete EN and obtain steady state conditions for the BNR processes in the BNRAS system in order to confirm the results of the first two investigations for an ENBNRAS system operating at steady state.

(ii) Evaluate anoxic P uptake BEPR under steady state conditions.

(iii) Monitor the interaction between anoxic and aerobic P uptake, and to identify the conditions that trigger the shift between anoxic and aerobic P uptake and the effect this has on the overall BEPR performance.

(iv) Compare the overall BNR performance of the ENBNRAS system with that of a 'conventional' BNRAS system with equivalent design and operating parameters receiving the identical wastewater as influent.

A detailed description of this laboratory scale ENBNRAS system and the experimental investigation is presented in Chapter 3.

CHAPTER 2

LITERATURE REVIEW

2.1 ANOXIC PHOSPHORUS UPTAKE

The earlier activated kinetic sludge models that include biological excess phosphorus removal (BEPR), such as the UCTPHO (Wentzel *et al.*, 1992) and IAWQ ASM No.2 (Henze *et al.*, 1995) considered only aerobic P uptake polyphosphate accumulating organisms (PAOs). Even though these kinetic models drew process and stoichiometric information substantially from the biochemical PAO behaviour models of Wentzel *et al.* (1986) and Comeau *et al.* (1986), which include denitrification by PAOs, the experimental data from which the kinetic BEPR models were developed and calibrated were from laboratory systems which exhibited mainly aerobic P uptake (>90%), in particular (i) the enhanced PAO cultures system of Wentzel *et al.* (1989) and (ii) the mixed cultures system receiving real wastewater of Clayton *et al.* (1991) and summarised by Wentzel *et al.* (1990).

Since 1990, significant anoxic P uptake has been observed more frequently in laboratory scale systems (Kerrn-Jespersen and Henze, 1993; Kuba *et al.*, 1993) and at full scale (Kuba *et al.*, 1997). Ekama and Wentzel (1999) also observed anoxic P uptake in a number of laboratory scale MUCT type systems at 10 and 20 days sludge age. Bortone *et al.* (1996) and Sorm *et al.* (1996) developed the DEPHANOX system (see Section 2.2 below for details) to maximise anoxic P uptake and hence utilise the RBCOD stored in the PAOs for denitrification. Very high anoxic P uptake (>50%) has also been observed in the external nitrification (EN) biological nutrient removal activated sludge (BNRAS) systems of Hu et al. (1999) and Moodley *et al.* (1999) (see Section 2.3 below).

In a description and review of the denitrification and BEPR behaviour in nitrifying/denitrifying (ND) and NDBEPR systems, Ekama and Wentzel (1999) report that in ND systems, the only heterotrophic organisms that are present are the ordinary heterotrophic organisms (OHOs), and therefore denitrification is ascribed to the OHOs only. In NDBEPR systems polyphosphate accumulating organism (PAO) heterotrophs are also present. From the above, two types of P uptake behaviour in BEPR have been observed: (i) P uptake that occurs in the aerobic zone only, and (ii) P uptake that takes place in the anoxic and the aerobic zones of a system. For (i), with no anoxic P uptake, denitrification is mediated by the OHOs only, since there is no PAO activity in the anoxic reactor. The inactivity of the PAOs in the anoxic zones was confirmed by Clayton *et al.* (1991) who conducted a series of anoxic batch tests and reported that no P uptake or PHB utilisation was observed under anoxic conditions, and this implies that with only aerobic P uptake, PAOs did not take part in the denitrification process. For (ii), where P uptake occurs in the anoxic as well as in the aerobic zones, the PAOs take part in the denitrification process by utilising a portion of the internally stored PHB to denitrify. There seem to be distinct differences in the P removal performance in purely aerobic P uptake BEPR and anoxic/aerobic P uptake BEPR. Conventional NDBEPR systems with only aerobic P uptake BEPR have shown $P_{release}/P_{removal}$, $P_{removal}$/Influent RBCOD and $P_{removal}$/Influent COD ratios of 3.0, 0.11 and 0.021 respectively, and these ratios conform to the steady state BEPR model of Wentzel *et al.* (1990). With anoxic/aerobic P uptake BEPR these ratios seem to be lower, at 1.5 - 2.0, 0.06 - 0.08 and 0.012 - 0.015 respectively (Ekama and Wentzel, 1999). Furthermore, the BEPR is reduced to about ⅔rds to ¾ths of that which would be expected to occur under purely aerobic P uptake BEPR. In order to match the calculated P removal with the model of Wentzel *et al.* (1990) to the lower values observed under anoxic/aerobic P uptake BEPR, the P content of the PAOs ($f_{XBG,P}$) needed to be lowered from 0.38 mgP/mgPAOAVSS to 0.10 - 0.28 mgP/mgPAOAVSS.

2.2 THE DEPHANOX SYSTEM

The DEPHANOX system (Figure 2.2) was developed by Bortone *et al.* (1996) and Sorm *et al.* (1996) to stimulate and exploit anoxic P uptake. The DEPHANOX system configuration developed from the idea that single sludge treatment plants do not avoid the use of the carbon source under aerobic conditions, while separate systems (anaerobic/anoxic and aerobic) could lead to an improved performance by making more efficient use of the available carbon source. Configurations that drive electrons to the reduction of nitrates are therefore favourable. In effect, by stimulating the PAOs to take up P in the anoxic zone, utilisation of influent RBCOD is re-captured for denitrification. With aerobic P uptake BEPR, the influent RBCOD is lost to denitrification because the influent RBCOD taken up in the anaerobic reactor is utilised by the PAOs in the aerobic reactor. With anoxic P uptake, this influent RBCOD is to a greater or lesser extent, depending on the magnitude of anoxic P uptake, utilised in the anoxic reactor with nitrate as electron acceptor and adds to the denitrification by the OHOs.

To stimulate and maximise anoxic P uptake, very large anoxic mass fractions are required. However, with large anoxic mass fractions in NDBEPR systems, the aerobic mass fraction is small and not sufficient to sustain nitrification in the system. To avoid the loss of nitrification in the system, Bortone *et al.* (1996) and Sorm *et al.* (1996) developed the DEPHANOX system, in which the nitrification process is removed from the suspended medium and transferred to an external fixed media system. This allowed the anoxic zone to be significantly enlarged at the expense of the aerobic zone without losing the benefit of nitrification.

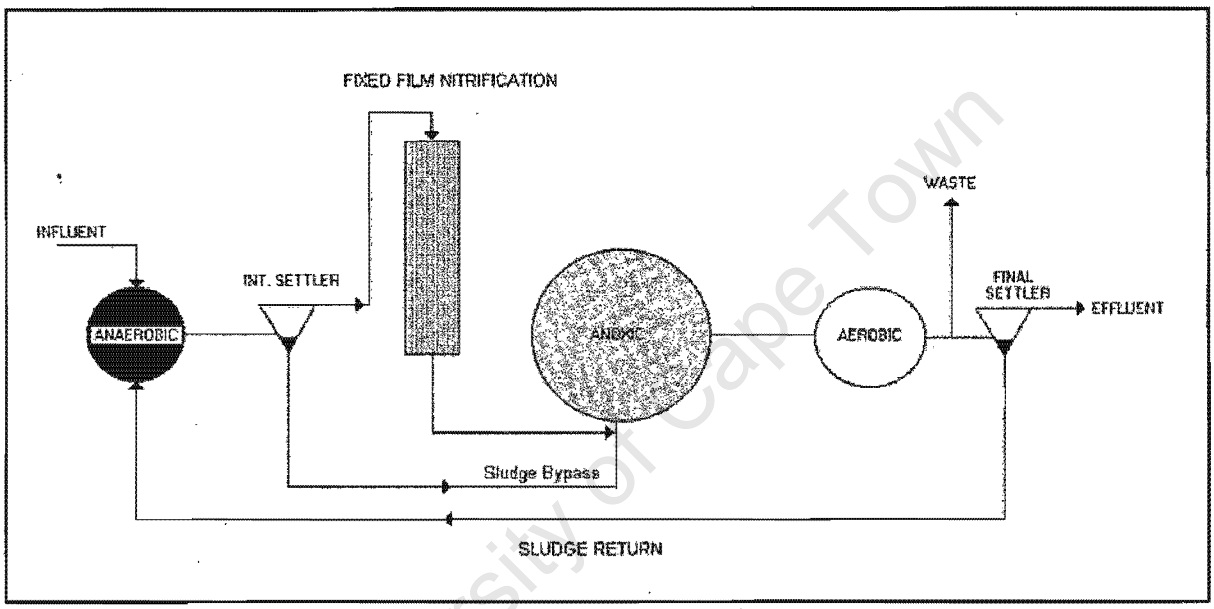

FIGURE 2.1 - Schematic layout of the DEPHANOX system developed by Bortone *et al.* (1996) and Sorm *et al.* (1996).

In the DEPHANOX system (Figure 2.1), the influent is discharged to the anaerobic reactor to stimulate BEPR. The main system sludge is then separated from the bulk liquid in the internal settling tank. The sludge is passed directly to the anoxic reactor, while the FSA rich supernatant is routed through the external nitrifying fixed medium system for nitrification. The nitrate rich effluent from the fixed medium system is passed to the main anoxic reactor for denitrification. After the anoxic reactor there is a small aeration reactor followed by the final settling tank where the system sludge is returned to the anaerobic reactor, and the overflow flows out of the system as effluent. The aerobic reactor no longer having to support nitrifiers, is included mainly for re-aeration purposes and completing the P uptake process aerobically and is therefore small, allowing for a very high anoxic mass fraction to stimulate and maximise anoxic P uptake.

The DEPHANOX system proved successful, because it stimulates anoxic P uptake thereby promoting the utilisation of the organic substrate for the P and N removal biological processes with minimal substrate 'loss' in the aerobic zone and facilitates the utilisation of the RBCOD sequestered by the PAOs for denitrification in the anoxic zone by anoxic P uptake. From research on laboratory scale DEPHANOX systems, Bortone *et al.* (1996) and Sorm *et al.* (1996) found a high P uptake in the anoxic reactor with a removal efficiency of ~71% with continued P uptake in the re-aeration reactor, allowing very low P values in the effluent. It should however be noted that the influent wastewater contained a high organic P fraction and a very low ortho-P fraction. It was estimated that the P uptake rate in the aerobic reactor was double that occurring in the anoxic reactor. Consistent full nitrification was achieved in the external nitrification system, but denitrification rates were low (~30 mgN/gVSS.d) giving a N removal efficiency of ~60%. It was also found that the DEPHANOX system produced a consistently good sludge settleability (SVIs ~50ml/g). It seems that, given the appropriate conditions, different species of PAOs which accomplish anoxic P uptake find a niche in the system, but which appear to have a significantly lower BEPR performance and use the influent RBCOD less 'efficiently' compared with the aerobic P uptake PAOs. Comparing the anoxic/aerobic BEPR performance results observed in the 'conventional' BEPR systems (see Section 2.1 above) with those observed in the DEPHANOX system, it seems that similarly low values for $P_{release}/P_{removal}$, $P_{removal}$/Influent RBCOD and $P_{removal}$/Influent COD ratios are obtained i.e., 0.52, 0.044 and 0.017 respectively with $f_{xbg,p}$ around 0.118. However, this comparison should be regarded as approximate because (i) the DEPHANOX system showed significant variation in behaviour in its five 'steady state' periods, in particular in the mass of VSS in the system, (ii) COD balances could not be checked because the aerobic reactor oxygen utilisation rate was not reported and (iii) the influent total P seemed to have a very low ortho-P fraction making P release results spurious. An advantage of the DEPHANOX system configuration over the use of internal fixed media for nitrification improvement (see Section 2.3 below) is that by nitrifying externally, the overgrowing of the slow growing nitrifiers on the internal fixed medium by the OHOs in the mixed liquor is avoided. The potential of BNRAS system intensification that results when the process of nitrification is removed from the main system AS was not considered in the investigations on the DEPHANOX system; these are discussed below.

2.3 EXTERNAL NITRIFICATION BIOLOGICAL NUTRIENT REMOVAL ACTIVATED SLUDGE (ENBNRAS) SYSTEMS

The requirement to nitrify governs the sludge age of the BNRAS system. For maximum specific growth rates of nitrifiers at 20°C (μ_{nm20}) around 0.45/d, to guarantee nitrification, the sludge age of the single sludge system must be around 20 to 25 days at 14°C, if 40 to 50% of the sludge mass is aerated. Such long sludge ages result in large biological reactors per Ml wastewater treated. To reduce the sludge age and hence the biological reactor volume per Ml treated, internal fixed media such as Ringlace™ have been placed in the aerobic reactor (Wanner *et al.*, 1988; Sen *et al.*, 1994, 1995; Randall *et al.*, 1996). The nitrifiers grow on the fixed media establishing a population permanently resident in the aerobic reactor. These nitrifiers are not subject to either the aerobic sludge mass fraction or the suspended mixed liquor sludge age, with the result that both can be reduced. Such a reduction in system sludge age is particularly beneficial for low temperature wastewaters (10 - 15°C). However, the effectiveness of the internal fixed media has not been as good as expected, and yields a low cost/benefit ratio.

Hu *et al.* (1999) proposed that external nitrification (EN), i.e. external to the BNRAS system, will provide a more effective reduction in sludge age and aerobic mass fraction. If nitrification can be achieved independently of the BNRAS mixed liquor, the sludge age can be reduced from the usual 20 to 25d to less than half, around 8 to 10d. The reduction in sludge age increases the WW treatment capacity of the system by some 50% or, alternatively, reduces the biological reactor volume requirement per Ml wastewater treated by about ⅓rd, without negatively impacting either biological N or P removal. In fact, a reduction in sludge age increases both biological N and P removal per mass organic load (Wentzel *et al.*, 1990) and this would be particularly beneficial for low temperature wastewaters. Because nitrification is no longer required, the aerobic mass fraction is governed by the P uptake process, for which aerobic mass fractions can be smaller than for nitrification.

EN can be achieved at wastewater treatment plants (WWTPs) where old trickling filters (TFs) have been extended with a BNRAS system. There are many such WWTPs, particularly in South Africa. Often at these WWTP's, to retain the benefit of the old TFs, a portion of the influent wastewater is passed through the TFs and the effluent is either (i) irrigated to land at the WWTP, (ii) chemically treated to precipitate the P before discharging to the BNRAS system or the environment, or (iii) discharge to the BNRAS system for biological N and P removal. If, instead of these three strategies, the nitrification process is transferred to the TFs, all the WW flow can be discharged to the BNRAS system resulting in BNR on the entire WW flow. In this way the TFs assist the BNRAS system in the area of weakness, i.e. nitrification, rather than taking away from its strength, i.e. biological N and P removal with influent organic material (see Chapter 1 for further details).

2.3.1 An Economic Evaluation for the Implementation of the ENBNRAS System at Full Scale

Little *et al.* (2000) performed an economic evaluation on the implementation of the ENBNRAS system at full scale for the Potsdam wastewater treatment plant at Milnerton in Cape Town, South Africa. The Potsdam treatment plant comprises old trickling filters with a capacity of 18 Ml/d that have been extended with a new BNRAS system with a 17 Ml/d capacity, resulting in a combined capacity of 35 Ml/d. The influent sewage flow is split equally and half of the influent flow is treated on the old trickling filters, while the other half is treated in the BNRAS system. The trickling filter effluent can be treated chemically with aluminium sulphate or ferric chloride for P removal and lime dosing facilities for alkalinity and pH correction are also provided if required. The activated sludge plant is designed to remove P biologically and is expected to achieve <1 mgP/l in the effluent. Chemical P removal as for the trickling filters is also provided for backup purposes. The current flow is in the order of 26 Ml/d, and the existing plant capacity of 35 Ml/d is expected to be reached by 2005. The flow in 2020 is expected to be 49 Ml/d.

The engineering and economic evaluation by Little *et al.* (2000) provide system flow schemes and capital, operation and maintenance costs for the following scenarios:

(1a) A greenfields BNRAS system with 13 days sludge age and a capacity of 35 Ml/d (for a 15 year period, 2000 to 2015).

(1b) A greenfields ENBNRAS system with 8 days sludge age and a capacity of 35 Ml/d for the same 15 year period.

(2a) Increasing the capacity of the existing plant so that all 35 Ml/d can be treated in an extended 13 days sludge age BNRAS system (i.e. decommission the old trickling filters and double the capacity of the existing BNR system) - for the period 2000 to 2005.

(2b) Converting the existing plant to an ENBNRAS system with a 8 days sludge age, by rehabilitating the old trickling filters and using them for external nitrification purposes and hence obtaining BNR on the full 35 Ml/d influent flow - for the period 2000 to 2005.

(3a) Keeping the existing plant unchanged until 2005, after which (2a) is implemented, but with a capacity of 49 Ml/d - for the period 2000 to 2020.

(3b) Keeping the existing plant until 2005, after which (2b) is implemented, but with a capacity of 49 Ml/d - for the period 2000 to 2020.

In Table 2.1 the costs for each scenario are given in their net present value (NPV) at 6%, and they include all civil construction costs, mechanical construction costs and operational as well as maintenance costs.

TABLE 2.1 - NPV at 6% for the implementation of a 'conventional' BNRAS system or a ENBNRAS system at the Potsdam WWTP in Cape Town, South Africa.

Project	Period	NPV at 6% (in million ZAR)
Greenfields 35 Ml/d plant		
(1a) Conventional BNRAS system	2000 - 2015	147.44
(1b) ENBNRAS system	2000 - 2015	138.25
Conversion of existing plant to a 35 Ml/d plant		
(2a) Conventional BNRAS system (decommission TFs)	2000 - 2006	93.55
(2b) ENBNRAS system, using old TFs	2000 - 2006	76.50
Conversion of existing plant to a 49 Ml/d plant in 2005		
(3a) As for (2a) above	2000 - 2020	164.80
(3b) As for (2b) above	2000 - 2020	154.27

Table 2.1 shows that the overall costs of the ENBNRAS system are lower than those for a 'conventional' BNRAS system. It is important to note that:

- The ENBNRAS system uses less oxygen and hence less electricity and therefore the power costs are less.
- The ENBNRAS system produces more waste sludge which results in higher costs for sludge dewatering, transport and landfill disposal (the current practice at Potsdam).
- The capital costs for the ENBNRAS system works are about 20% cheaper.

- The operating costs dominate the overall results for both the 'conventional' BNRAS system and the ENBNRAS system. The operating costs make up about 70% of the total cost, which are essentially the same for both configurations.

2.3.2 Discharge Water Quality Legislation in South Africa

The discussion on the WWTPs where old TFs have been extended with BNRAS systems and where a portion of the influent wastewater flow continues to be treated on the TFs, raises the question of effluent quality and the regulations that apply to these from South African WWTPs. The Department of Water Affairs and Forestry (DWAF) is currently revising the effluent discharge standards and it is useful to place the implementation of the ENBNRAS system in South Africa in the context of the proposed revised effluent discharge standards.

Historically, the Water Act of 1956 was passed requiring treated effluents to be returned to the water catchments from where the water originated, subject to effluent discharge standards. The effluent discharge standards published in terms of the Water Act of 1956 (see Table 2.2) required >90% COD removal to avoid deoxygenation of the receiving water bodies as well as the nitrification of the FSA to effluent values below 10 mgN/l FSA to avoid deoxygenation of and the toxicity effect on the receiving water bodies. After the development of BNRAS systems for the treatment of municipal wastewater in the early 1970's and in-depth research on the BNRAS systems, the special standard for phosphate was promulgated in 1980, to be enforced in 1985. This special standard for phosphate required selected treatment plants discharging effluents to sensitive catchment areas to remove P to values less than 1 mgP/l dissolved ortho-P (see Table 2.2). Further research indicated that the eutrophication occurring in some water bodies in South Africa was N rather than P limited, and therefore the special standard for N removal was promulgated and enforced from 1984 onwards (see Table 2.2). The effluent quality standards from the general standards of the Water Act of 1956 as well as the special standards for P and for N are listed in Table 2.2. The standards listed in Table 2.2 are uniform effluent standards, and all sewage treatment plants operated in South Africa irrespective of size must comply with the relevant standard applicable. The standards are still enforced in South Africa today.

TABLE 2.2 - Water quality discharge standards for the general standard, special standard for N and special standard for P.

Parameter	Units	General Standard	Special Standard (N)	Special Standard for Phosphate
Filtered COD	mgCOD/l	<75	<75	-
FSA	mgN/l	<10	<1	-
Nitrate	mgN/l	-	<1.5	-
Phosphate	mgP/l	-	-	<1
Suspended Solids	mg/l	<25	<10	-
DO	% Saturation	>75	>75	-
pH	-	5.5 - 9.5	5.5 - 7.5	-

The DWAF is currently in the process of revising the effluent quality standards, as the old general standard is not considered to be sufficient in the framework of the newly developed policy of waste load allocation, receiving water quality objectives and minimum requirements. New effluent quality standards have been proposed (see Table 2.3) and are due to become law soon, under the new National Water Act of 1998. The proposed new standards differentiate between WWTPs with secondary treatment only and those with secondary and tertiary treatment and stipulate separate effluent quality requirements for each. WWTPs wishing to discharge effluents that are not within the proposed new standards need to apply to the DWAF for special permission to do so. Table 2.3 lists the proposed new effluent quality standards for WWTPs with secondary treatment only and for WWTPs with secondary and tertiary treatment.

TABLE 2.3 - Water quality discharge standards proposed under the new National Water Act of 1998.

Parameter	Units	Secondary Treatment Only	Secondary and Tertiary Treatment
COD	mgCOD/l	65	50
FSA	mgN/l	3	2
Nitrate	mgN/l	8	7
Phosphate	mgP/l	-	0.8
Suspended Solids	mg/l	18	15

A firm of consulting engineers, Wates, Meiring and Barnard (1999) undertook a BNR technology performance evaluation to assess the measure with which the BNR systems as implemented in South Africa over the past 25 years achieve the old (Table 2.2) and proposed new (Table 2.3) effluent quality standards. 17 secondary treatment plants (N removal only) and 31 advanced secondary treatment plants (N and P removal) were analysed in terms of treated effluent quality variables of COD, SS, FSA, nitrate and dissolved ortho-P. On the basis that the potential of BNR technology is the 95 percentile performance (i.e. achieves performance 95% of the time) of the 25th percentile plant (i.e. 25% of plants have better performance and 75% worse), the results of the survey of operating N as well as N and P removal activated sludge plants in South Africa indicate that the BNRAS technology as implemented in South Africa has the potential to achieve effluent concentrations of 50 mgCOD/l, 15 mgSS/l, 2.0 mgN/l FSA, 7.0 mgN/l nitrate and 0.8 mgP/l ortho-P. This is better than the proposed secondary plus tertiary (2° + 3°) treatment requirements for the COD and nitrate effluent concentrations, but poorer for the SS, FSA and dissolved ortho-P concentrations. The performance of the ENBNRAS system will be evaluated against the proposed 2° + 3° treatment effluent quality requirements in Chapter 4.

2.3.3 Laboratory Studies on ENBNRAS Systems

Hu *et al.* (1999) and Moodley *et al.* (1999) performed a 250 day and 373 day investigation respectively on two laboratory scale ENBNRAS systems in the Water Research Laboratory at the University of Cape Town. Figure 2.2 shows the general experimental system setup and Table 2.4 the design and operating parameters of the two systems.

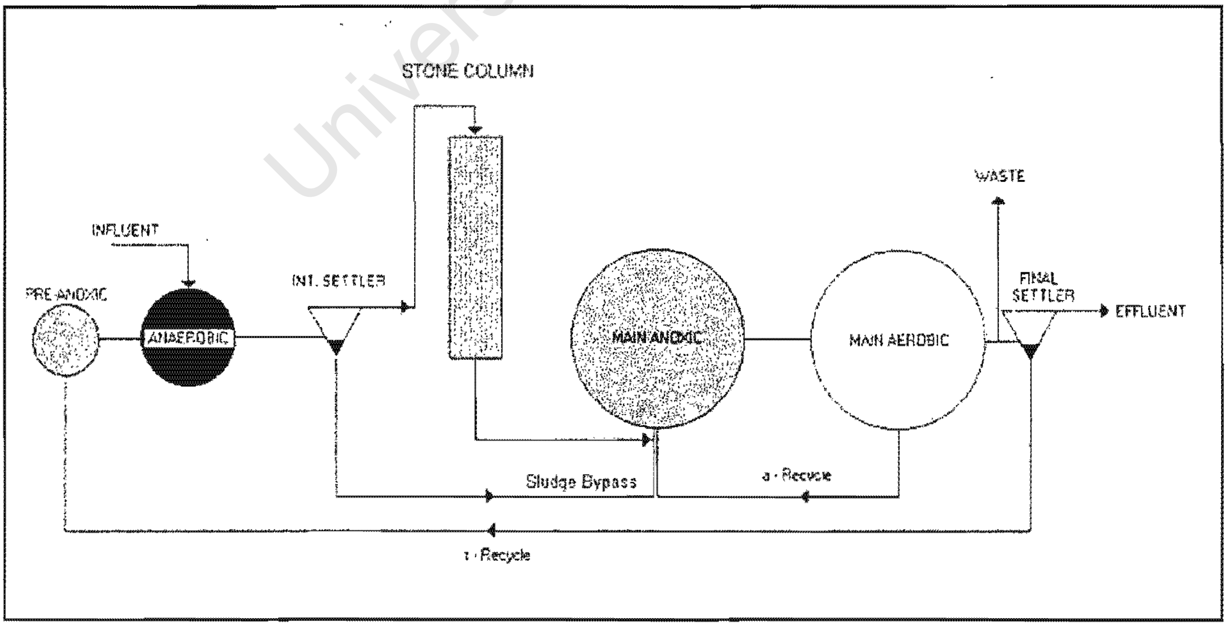

FIGURE 2.2 - Schematic layout of the laboratory scale ENBNRAS systems investigated by Hu *et al.* and Moodley *et al.*

TABLE 2.4 - Design and operating parameters for the ENBNRAS systems of Hu *et al.* (1999) and Moodley *et al.* (1999).

System Parameter	**Hu *et al.* (1999)**	**Moodley *et al.* (1999)**			
	Configuration	**Config. 1**	**Config. 2**	**Config. 3**	**Config. 4**
No. of Days	250	30	124	51	164
Sludge Age (d)	10	10	8	10	10
Influent Feed (l/d)	20	20	40	30	30
COD (mgCOD/l)	717	709	677	646	716
TKN/COD Ratio	0.06 to 0.11	0.08 to 0.11	0.07 to 0.12	0.07 to 0.14	0.04 to 0.15
Nitrate Dose (as influent TKN/COD ratio)	0.015 (mean)	0.03 to 0.04	0.01 to 0.03	0.02 to 0.03	0.02
EN System used	Stone Colum	Stone Colum	Stone Colum	Stone Colum	Suspended A.S.
Total System Volume (l)	21	20	20	20	20
Pre-Anoxic Reactor Vol. (l)	2	2	3	3	3
Anaerobic Reactor Vol. (l)	5	5	5	5	5
Main Anoxic Reactor Vol. (l)	10	10	9	6	6
Main Aerobic Reactor Vol. (l)	4	3	3	6	6
Aerobic Mass Fraction	0.19	0.15	0.15	0.3	0.3
Anoxic Mass Fraction	0.57	0.60	0.60	0.45	0.45
Anaerobic Mass Fraction	0.24	0.25	0.25	0.25	0.25
s-recycle (w.r.t influent flow)	1 : 1	0.5 : 1	0.5 : 1	0.5 : 1	0.5 : 1
a-recycle (w.r.t influent flow)	0	0	0	1 : 1	1 : 1
Sludge Bypass (w.r.t infl. flow)	0.25 : 1	0.5 : 1	0.25 : 1	0.33 : 1	0.43 : 1
Flow to EN System (l/d)	35	30	50	35	32

From Figure 2.2 it can be seen that an anoxic reactor was installed preceding the anaerobic reactor. The purpose of this pre-anoxic reactor is to denitrify any residual nitrate that may be present in the underflow (s) recycle, before it flows into the anaerobic reactor where the nitrate has a negative impact on the P release in the anaerobic reactor and hence the system P removal. In essence, the pre-anoxic reactor was installed to protect the anaerobic reactor, and hence the system BEPR, from the effects of excess nitrate flowing into the anaerobic reactor. In Table 2.4 the pre-anoxic reactor volumes given are effective volumes at the aerobic reactor VSS concentration - the actual volume was 1 l throughout both investigations.

In the first investigation by Hu *et al.* (1999), 13 sewage batches were fed to the system. Nitrate was dosed to the main anoxic reactor to (i) determine the denitrification potential of this reactor and (ii) observe the influence of anoxic P uptake on the biological excess P removal (BEPR) in the system. The objectives of the investigation were to assess:

(i) The impact of EN on the suspended medium system COD removal, nitrification, denitrification, N removal and BEPR performance.

(ii) If anoxic P uptake BEPR is to be exploited in the system, is anoxic P uptake BEPR as good as aerobic P uptake BEPR?

(iii) What factors promote anoxic P uptake.

(iv) Whether the ENBNRAS system consistently produced sludge that settled well.

From the 250 days investigation, Hu *et al.* report the following:

- Overall average COD and N mass balances over the system of 89% and 91% respectively.
- Removal of 92% of the influent COD.
- Average total N in the effluent of 11.5 mgN/l, of which 7.8 mgN/l was TKN (of which 6.4 mgN/l was FSA) and 3.7 mgN/l was NO_X. Total N removal was 86%, including the nitrate dosed to the main anoxic reactor, which effectively increased the influent TKN/COD ratio to ~0.14 mgN/mgCOD.
- Virtually complete nitrification in the EN system, and on average 88% of the system nitrification occurred externally.
- The highest recorded denitrification potential of the main anoxic reactor was 58 mgN/l influent.
- Overall average P removal of 9.5 mgP/l influent with considerable anoxic P uptake in the main anoxic reactor. Initially 29% of the total P uptake occurred in the anoxic reactor and this percentage increased steadily throughout the investigation to 70% anoxic P uptake at the end of the investigation. Steady state was therefore not achieved with respect to anoxic P uptake.
- $P_{release}/P_{uptake}$, $P_{release}/P_{removal}$, $P_{removal}$/Influent COD and $P_{removal}$/Influent RBCOD ratios of 0.708, 3.420, 0.0123 and 0.0690 respectively, which were significantly different to these ratios for aerobic P uptake BEPR.
- Average OUR of 29 mgO/(l.h) in the 19% aerobic mass fraction, which is about 2.5 times (60%) lower compared with the OUR in a 'conventional' BNRAS system.
- Overall average DSVI of ~60ml/g with *Microthrix parvicella*, type 0092 and type 0675 the main filaments in the mixed liquor, all at low levels.

With regard to the operation of the ENBNRAS system, Hu *et al.* report that if nitrifiers are supported in the mixed liquor of the main system (they are difficult to exclude from the main system because they slough off the fixed media into the system), then virtually complete nitrification in the EN system is essential to limit nitrate production in the main aerobic reactor and keep the nitrate load on the pre-anoxic reactor low. If the pre-anoxic reactor is overloaded, nitrate will flow into the anaerobic reactor and reduce the BEPR performance. Because the sludge settled so well, the underflow (s) recycle could be reduced to 0.5:1 to reduce nitrate return to the pre-anoxic reactor. It was noted that the BEPR in the ENBNRAS system with anoxic P uptake was about ⅔ of that expected from systems that have >95% aerobic P uptake ('normal' BEPR). This reduced BEPR with significant anoxic P uptake has also been observed in conventional (internal nitrification UCT and 3 stage Bardenpho) NDBEPR systems (Ekama and Wentzel, 1999). Hu *et al.* conclude that two factors appear to stimulate anoxic P uptake: (i) A high nitrate load on the main anoxic reactor (i.e. a high influent TKN/COD ratio) and (ii) a small aerobic mass fraction to limit aerobic PAO activity.

The objectives of the investigation of Moodley *et al.* (1999), which followed immediately after that of Hu *et al.* reviewed above and used the same experimental system, were to:

(i) Double the volume of influent wastewater to test one of the claimed advantages of ENBNRAS systems arising from the shortened sludge age and improved sludge settleability.

(ii) Promote conditions to achieve aerobic P uptake BEPR in the system to maintain maximal P removal.

(iii) Increase the aerobic mass fraction in an attempt to quantify its effect on anoxic P uptake.

(iv) Study the effect of the increase in aerobic mass fraction on the sludge settleability of the ENBNRAS system.

The system of Moodley *et al.* (1999) was operated in four different configurations in the 373 day investigation. Table 2.4 gives a summary of the main design and operating parameters for the four different configurations. Configuration 1 (30 days, 3 sewage batches) was essentially a take over period from Hu *et al.* (1999). For Configuration 2 (124 days, 17 sewage batches), the influent flow was doubled and the underflow (s) recycle ratio reduced to 0.5:1. This increased the mass of VSS in and effective volume of the pre-anoxic reactor (which remained at 1l actual volume) to 3l. Accordingly, the main anoxic reactor volume was reduced by 1 l to 9 l. The hydraulic flow on the EN system increased from 30 to 50 l/d, which together with moth fly (Psychoda) infestations produced increasingly poorer nitrification efficiency. The low nitrate load on the main anoxic reactor and the small aerobic reactor (3 l) limited both anoxic and aerobic P uptake resulting in poor BEPR. In order to stimulate aerobic P uptake in the system, the aerobic reactor volume was increased at the expense of the main anoxic reactor volume to produce Configuration 3 (51 days, 4 sewage batches). Because this would have stimulated nitrification of the high FSA concentration from the poorly nitrifying stone column in the aerobic reactor, an a-recycle of 1:1 from the aerobic to the anoxic reactor was introduced to increase the denitrification and lower the nitrate concentration in the aerobic reactor and hence in the underflow (s) recycle. The nitrification performance of the stone column continued to decline, resulting in high nitrification in the aerobic reactor, which adversely affected the BEPR. A better laboratory scale EN system than the stone column was needed. A completely mixed activated sludge (AS) EN system was introduced, resulting in Configuration 4 (164 days, 12 sewage batches). Instead of the nitrifying bacteria growing on fixed media in the stone column, in the AS system they were suspended in a satellite completely mixed reactor with its own settling tank. This EN system nitrified efficiently and consistently and so solved the problem of incomplete external nitrification caused by the poor nitrification performance of the laboratory scale stone column. The overall average results given in the summary below are overall averages over all four system configurations over the entire 373 day investigation (average results of each configuration given by Moodley *et al.*, 1999).

From the 373 day investigation, Moodley *et al.* (1999) report the following:

- Overall average COD mass balance of 80% and overall average N mass balance of 91%.
- 91% removal of influent COD.
- Overall average total N in the effluent of 23 mgN/l, of which about 19.2 mgN/l was TKN (of which 15.4 mgN/l was FSA) and 3.8 mgN/l was NO_X.
- 72% total N removal (including the nitrate dosed to the main anoxic reactor to make up for the loss of nitrate from the poorly denitrifying stone column; see Table 2.4 for details).
- Overall average OUR of 35 mgO/l.h for Configurations 1 and 2, and 38 mgO/l.h for Configurations 3 and 4.
- TSS and VSS concentrations of 2628 mgTSS/l and 2163 mgVSS/l respectively, resulting in a TSS/VSS ratio of 0.82.
- Average calculated unbiodegradable particulate COD fraction ($f_{S,UP}$) of 0.11.
- EN system nitrification efficiency of >88% initially, deteriorating to <50% in Configuration 3 because of hydraulic overloading and *Psychoda* infestation of the stone column.
- Overall average of 29 mgN/l denitrification in the main anoxic reactor.
- A P removal of 10.37 mgP/l influent, with an average of 21.0 mgP/l influent P release and

30.2 mgP/l influent P uptake. On average, 56% of the total P uptake occurred in the anoxic reactor.

- Average calculated P content of PAOs ($f_{XBG,P}$) of 0.312 mgP/mgPAOAVSS in terms of the BEPR model of Wentzel *et al.* (1990).
- $P_{release}/P_{uptake}$, $P_{release}/P_{removal}$, $P_{removal}$/Influent COD and $P_{removal}$/Influent RBCOD ratios of 0.661, 1.950, 0.0151 and 0.1136 respectively.
- Overall average DSVI of 94 ml/g with an average of 2.8 mgN/l NO_X leaving the anoxic reactor and with *Microthrix parvicella*, type 1851 and type 0092 the main filamentous organisms in the mixed liquor.

Moodley *et al.* (1999) report further that a high nitrate load (brought about by a high influent TKN/COD ratio) and large anoxic mass fraction stimulate anoxic P uptake, as was indicated in the report by Hu *et al.* (1999). In addition, Moodley *et al.* state that an influent TKN/COD ratio of <0.14 mgN/mgCOD may be detrimental to the development of anoxic P uptake. It is stated further, that the inclusion and maximisation of aerobic P uptake in the ENBNRAS system is desirable to maximise the BEPR. However, the conditions that promote aerobic P uptake (i.e. a larger aerobic mass fraction) are also conducive to nitrifier growth and hence internal nitrification. If a larger aerobic mass fraction were to be introduced to maximise BEPR, virtually complete and consistent external nitrification would have to be guaranteed, else the pre-anoxic reactor would be overloaded to the detriment of BEPR, and this would be counter productive.

In their report Moodley *et al.* (1999) propose a method to calculate the denitrification rate by the PAOs to assess their contribution to the denitrification. The method follows the calculation procedure of Ekama and Wentzel (1999). This method essentially fractionates the measured VSS mass in the experimental system into active ordinary heterotrophic organism (OHO, $X_{B,H}$) and active PAO ($X_{B,G}$) masses, OHO and PAO endogenous masses ($X_{E,H}$ and $X_{E,G}$) and inert unbiodegradable organic mass from the influent (X_I). From such a VSS fractionation calculation, the concentration of influent RBCOD obtained by the PAOs is known, with the balance of the influent RBCOD and all of the influent slowly biodegradable (SB)COD available to the OHOs. To determine the contribution of the PAOs to the denitrification in the anoxic reactor, it is assumed that the total P uptake in the anoxic and aerobic zones results in the utilisation of all of the RBCOD obtained by the PAOs and that the % P uptake in the anoxic and aerobic zones reflects the % PAO RBCOD utilised in these respective zones. Thus, with say 40% anoxic P uptake, 40% of the influent RBCOD obtained by PAOs is utilised in the anoxic zone and 60% in the aerobic zone. The % anoxic P uptake is calculated from the experimental data measured on the BNR systems. With the COD concentration utilised by the PAOs in the anoxic reactor known, the nitrate denitrified with this COD in the PAO anoxic growth process can be calculated via the anoxic growth yield coefficient ($Y_{Ganoxic}$) and the oxygen equivalent of nitrate, i.e. 2.86 mgO/mgNO_3-N denitrified. In this calculation, it was accepted that $Y_{Ganoxic}$ is lower than the equivalent aerobic value ($Y_{Gaerobic}$) because under anoxic conditions ideally only 2 moles ATP are formed per pair of electrons transferred, whereas under aerobic conditions 3 moles of ATP are formed per pair of electrons transferred (Payne, 1991; Casey *et al.*, 1999); from bioenergetic calculations, this reduces $Y_{Gaerobic} = 0.666$ to $Y_{Ganoxic} = 0.545$. With the nitrate concentration denitrified by the PAOs calculated, the nitrate concentration denitrified by the OHOs is the difference between the observed nitrate concentration denitrified in the anoxic reactor and the nitrate concentration denitrified by the PAOs. The specific denitrification rate of the PAOs and OHOs, viz ${K_2}''_{PAO}$ and ${K_2}''_{OHO}$, is then obtained by dividing the calculated nitrate denitrification rate of the PAOs and OHOs by the active PAO and OHO VSS concentrations determined from the VSS fractionation calculation. In this way the observed denitrification rate is apportioned and expressed in terms of the specific organism group mediating denitrification. This steady state method can be applied only to anoxic reactors that are overloaded with nitrate, i.e. have significant nitrate concentrations in their outflow to ensure that the biological OHO and PAO denitrification potential is exceeded. With this method Moodley *et al.* (1999) calculated the specific denitrification rates of the OHOs and PAOs, and also calculated the specific denitrification rates of the active VSS (AVSS) ignoring the presence of the PAOs as in Clayton *et al.* (1991), viz. ${K_2}''_{OHO} = 0.1165$ mgNO_3-N/mgOHOAVSS.d, ${K_2}''_{PAO} = 0.0625$ mgNO_3-N/mgPAOAVSS.d and $K_2' = 0.1379$ mgNO_3-N/mgOHOAVSS.d. From this it can be seen that the PAO denitrification rate is low, 12 times lower than the OHO denitrification rate with RBCOD (K_1) in ND systems and less than half the rate of OHOs for slowly biodegradable (SB) COD in NDBEPR systems. At such a low PAO denitrification rate, one questions whether the original motive for stimulating anoxic P uptake - to re-capture the utilisation of influent RBCOD for denitrification is worth it, considering the reduction in BEPR it seems to lead to. This aspect will be examined in this investigation also.

2.3.4 The Anoxic-Aerobic (AA) Filament Bulking Hypothesis for BNRAS Systems

The consistently good settling sludge produced by the ENBNRAS systems can, in part, be explained by the AA filament bulking hypothesis for BNRAS systems of Casey *et al.* (1994). The filamentous organisms that lead to bulking sludges in BNRAS system in South Africa are of the low F/M type, for example *M.parvicella*, type 0092, type 0041, type 1841 and type 0675. Historically, the control of low F/M filaments has been to increase the F/M ratio by incorporating selector reactors (Chudoba *et al.* 1973). However, in a review of investigations into the efficiency of anoxic and aerobic selectors, Gabb *et al.* (1991) concluded that little evidence exists that low F/M filaments are controlled by these selector reactors. Casey *et al.* (1994) established that AA filaments proliferate under intermittent aeration conditions (as low F/M conditions did not appear to be the primary cause influencing the bulking, the filaments responsible were renamed AA filaments), but not under fully aerobic or fully anoxic conditions. In work with intermittently aerated nitrification-denitrification (IAND) systems, Casey *et al.* (1994) found that maximum filamentous organism proliferation occurred with an aerobic mass fraction between 30 and 35% of the total. The relationship between the DSVI and the percentage aerobic period (aerobic mass fraction) that was found for artificial (chemically made up) wastewater is shown in Figure 2.3. It was also established that the DSVI appeared to be linked to the nitrate concentration at the end of the anoxic period as the conditions switched from anoxic to aerobic.

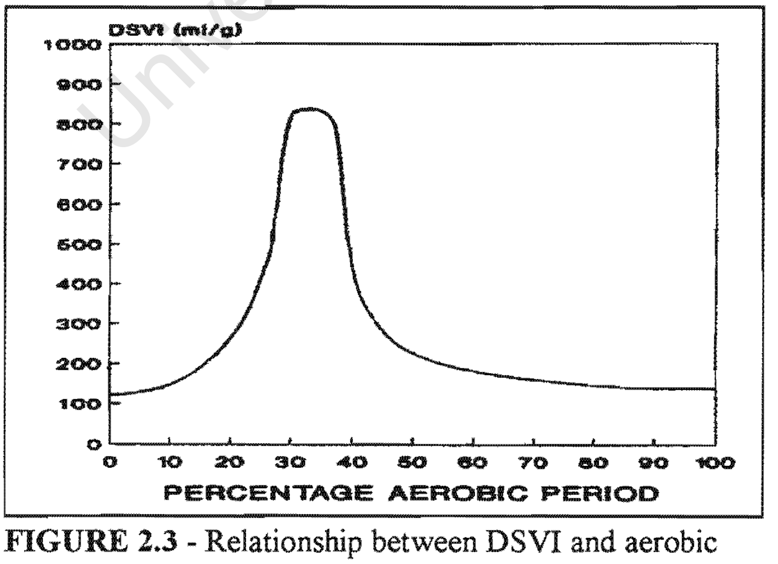

FIGURE 2.3 - Relationship between DSVI and aerobic mass fraction, as found by Casey *et al.* (1994).

Casey *et al.* (1994) developed a hypothesis for AA filament bulking, based on the biochemical model for aerobic-facultative behaviour of heterotrophic organisms proposed by Payne *et al.* (1973). In the biochemical model, Payne *et al.* (1973) proposed the following denitrification pathway:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

(nitrate → nitrite → nitric oxide → nitrous oxide → nitrogen gas)

Each of the nitrogen oxides are reduced at separate and specific enzyme complexes and one or more of the gaseous denitrification intermediates (NO, N_2O) that are generated under anoxic conditions have an inhibitory effect on the utilisation of substrate under subsequent aerobic conditions, as they interact with the enzymes responsible for oxygen reduction. Specifically, NO (nitric oxide) has been found to accumulate intra-cellularly during denitrification and this causes measurable and prolonged inhibition of oxygen utilisation in the subsequent aerobic conditions.

With this biochemical model as a basis, Casey *et al.* (1994) proposed the following hypothesis for AA filament bulking:

In BNRAS systems the majority of heterotrophic organisms can be classified by their morphology as either floc formers or filamentous organisms. Floc formers are hypothesised to reduce nitrate or nitrite to nitrogen gas under anoxic conditions, while filamentous organisms are hypothesised to be nitrate reducers, reducing nitrate to nitrite only. If nitrate or nitrite are present throughout the anoxic period, the floc formers reduce the nitrate or nitrite to nitrogen gas through each of the denitrification intermediates, resulting in the presence of some level of intra-cellular NO. When these floc formers are exposed to a subsequent aerobic conditions, the intra-cellular NO inhibits the utilisation of oxygen, and the floc formers continue to respire with nitrite (i.e. aerobic denitrification), but at a much reduced rate to that under anoxic conditions. In contrast, the filamentous organisms would not have any intra-cellular NO, because they effect only the first steps of the denitrification pathway, and are therefore not inhibited from utilising oxygen as an electron acceptor in the aerobic zone. This places the filamentous organisms at an advantage in the subsequent aerobic zone - they are able to utilise a greater portion of substrate under aerobic conditions than they would if the floc formers were not inhibited by the intra-cellular NO. The filamentous organisms are thereby able to increase their relative mass in the mixed liquor, resulting in a bulking sludge. When nitrate is not present throughout the anoxic period, viz. complete denitrification occurs, the floc formers are not inhibited in using oxygen under subsequent aerobic conditions. When denitrification is complete (<0.5 mgN/l in the anoxic reactor outflow) there will be no intra-cellular NO present and the floc formers are not at a disadvantage in the utilisation of substrate with oxygen in the aerobic zone. The concentration of nitrate flowing from the anoxic reactor is therefore an indication as to whether the filamentous organisms are at an advantage in the aerobic zone or not. High nitrate concentrations flowing from the anoxic reactor are conditions conducive to AA filament proliferation and bulking, while near zero nitrate concentrations in the anoxic reactor outflow are indicative of an uninhibited floc forming organism population and better settling sludges.

In 1998 Stewart Scott Consulting Engineers (Dr Casey) sought to determine the applicability in practice of the relationship between the DSVI and the aerobic mass fraction as reported for laboratory scale BNRAS systems by Casey *et al.* (1994). A survey of the operating conditions and plant characteristics of seven full scale BNRAS plants in Gauteng, South Africa was undertaken. The seven plants chosen were Daspoort (operated by the Pretoria Municipality), Rynfield and Vlakplaas (operated by ERWAT) and Goudkoppies, Bushkoppie, Olifantsvlei and Northern Works (operated by the Greater Johannesburg Metropolitan Council). These seven plants were chosen because they were the only plants at which historical data of their performance was available. It was intended also to measure the nitrate and nitrite concentration at the anoxic to aerobic condition transition, but this required immediate filtration and stabilisation of samples to stop the denitrification process in the sample, an important quality requirement that was difficult to ensure under operational conditions. However, the historical sludge settleability data was converted to DSVI units where applicable, analysed and an overall average DSVI value was calculated for each of the seven full scale sewage treatment plants. The results obtained are shown in Table 2.5 below.

TABLE 2.5 - DSVI values for seven full scale BNRAS treatment plants in Gauteng, South Africa.

Plant	DSVI (ml/g)	Percentage Aerobic Mass Fraction	Period of Analysis
Goudkoppies	93	60	Jul '97 - Jun '98
Bushkoppie (Unit 1)	61	76	Jan '98 - Dec '98
Olifantsvlei (Unit 3)	61	58	Jan '98 - Nov '98
Northern Works (Unit 4)	74	63	Jan '98 - Nov '98
Rynfield (South)	113	50	Jan '96 - Feb '97
Vlakplaats (Module D)	104	54	Jan '97 - Dec '97
Daspoort (Module 9)	162	44	Jan '95 - Mar '97

Figure 2.4 shows the DSVI and aerobic mass fraction data for the seven full scale treatment plants superimposed on the general DSVI/anoxic mass fraction diagram as reported by Casey *et al.* (1994).

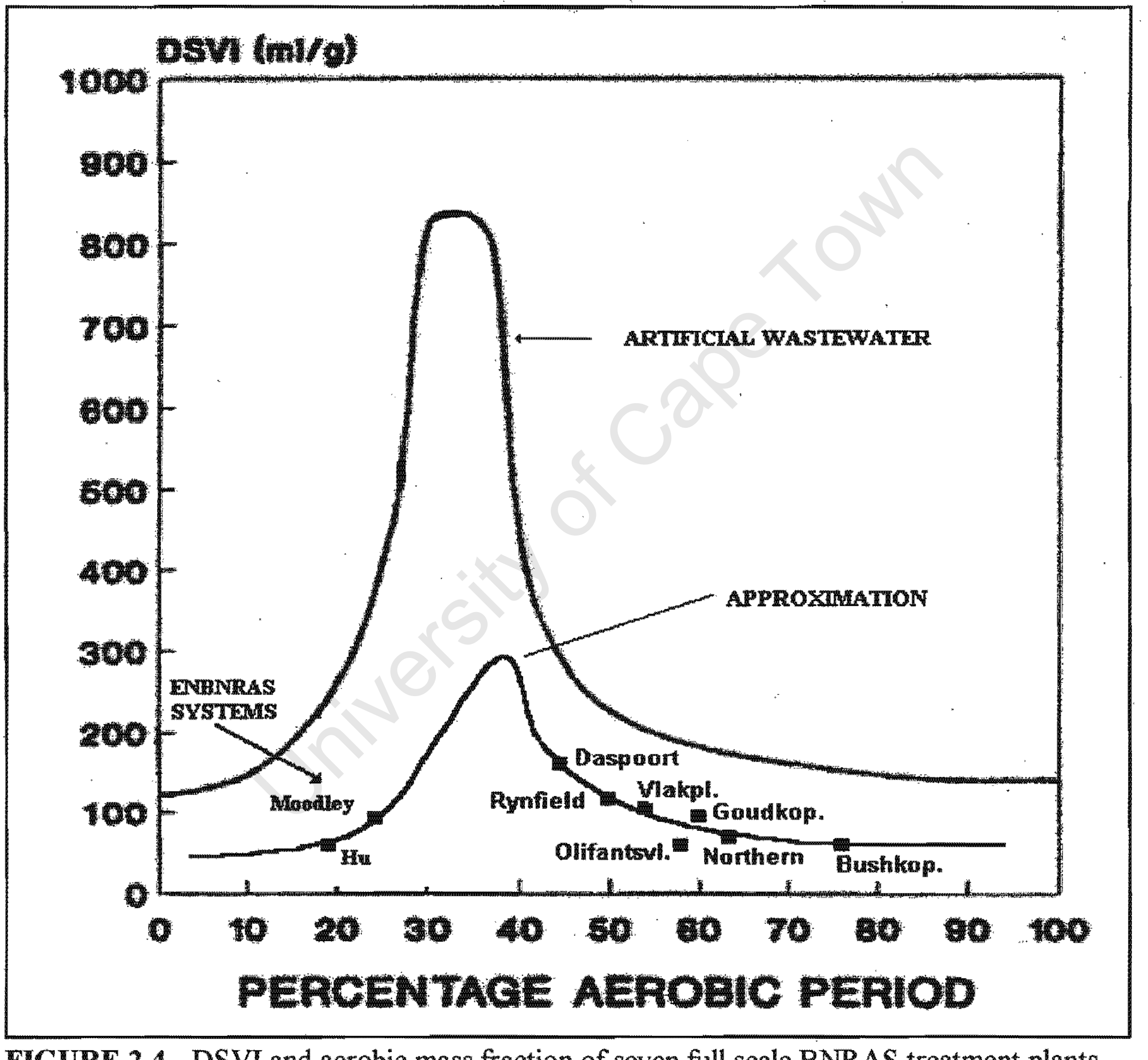

FIGURE 2.4 - DSVI and aerobic mass fraction of seven full scale BNRAS treatment plants superimposed on the DSVI/aerobic mass fraction relationship developed for artificial wastewaters by Casey *et al.* (1994).

It was concluded that a significant relationship exists between the two parameters, with improving sludge settleability for an aerobic mass fraction increase from 40% upwards. It was not possible to comment on aerobic mass fraction values of less than 40%, as full scale systems are not designed and operated at aerobic mass fractions below 40% because of the implications with respect to nitrification. The claim by Casey *et al.* (1994) that the poorest settling sludges develop in systems that operate at aerobic mass fractions in the range of 30 to 40% could therefore not be verified for the case of full scale BNRAS systems. However, since the full scale systems showed a significant relationship between their sludge settleability and the aerobic mass faction they were operated at for aerobic mass fractions greater than 40% (in accordance with that reported by Casey *et al.*, 1994) it seems as if the same can be expected for full scale systems operated at aerobic mass fractions in the range of zero to 40%. At the other end of the scale, the ENBNRAS systems of Hu *et al.* (1999) and Moodley *et al.* (1999) were operated at 19 and 25% aerobic mass fraction and produced consistently good settling sludges (see Figure 2.4).

2.3.5 Objectives of the Investigation of this Thesis

The investigations on a laboratory scale ENBNRAS system by Hu *et al.*(1999) established that:

- A laboratory scale stone column was effectively used as an EN system.
- EN has no apparent negative impact on either COD removal, nitrification, denitrification or N removal.
- An ENBNRAS system has the potential of producing effluents with <10 mgN/l total N, i.e. an ENBNRAS effects very good N removal.
- Significant anoxic P uptake occurs in the ENBNRAS systems, however P removal under anoxic P uptake BEPR is about ⅔rds of that expected from systems that have predominantly aerobic P uptake BEPR.
- It appears that a high nitrate load on the main anoxic reactor and a small aerobic mass fraction stimulate anoxic P uptake BEPR.
- The ENBNRAS system does produce sludges that settle well consistently.

The investigation of Moodley *et al.* (1999) further established that:

- The ENBNRAS system can produce good BNR on double the 'normal' influent wastewater flow without any deterioration in COD, N or P removal performance provided the EN system nitrifies virtually completely.

- A high nitrate load on the main anoxic reactor and a large anoxic mass fraction stimulate anoxic P uptake, and a TKN/COD ratio of <0.14 (for <20% aerobic mass fraction) may be detrimental to the development of anoxic P uptake and P removal.
- The inclusion and maximisation of aerobic P uptake is desirable for improved P removal performance of the system. However, the larger aerobic mass fractions required to maximise aerobic P uptake are conducive to nitrifier growth in the main system, and hence virtually complete and consistent EN would have to be guaranteed.
- Sludge settleability remains good (DSVI <110 ml/g) regardless of the aerobic mass fraction.
- If the EN system fails and the external nitrification efficiency deteriorates, the effects on the entire system will be significant. Underloading the main anoxic reactor with nitrate leads to a rapid decrease in anoxic P uptake. The high FSA concentrations flowing from the EN system into the main aerobic reactor are nitrified causing high nitrate or FSA concentrations (depending on the degree of nitrification in the main aerobic reactor) in the effluent and underflow (s) recycle. A high nitrate concentration in the underflow (s) recycle overloads the pre-anoxic reactor, and the excess nitrate flows into the anaerobic reactor causing a marked decrease in P release and hence in the overall P removal performance of the system.

In light of the research conducted so far, the main objectives of this investigation on the ENBNRAS system are:

(i) Achieve consistent virtually complete EN (by utilising the suspended AS EN system instead of a laboratory scale stone column) and obtain steady state conditions for the BNR processes in the BNRAS system in order to confirm the results of the first two investigations for an ENBNRAS system operating at steady state.

(ii) Evaluate anoxic P uptake under steady state conditions.

(iii) Monitor the interaction between anoxic and aerobic P uptake, and to identify the conditions that trigger the shift between anoxic and aerobic P uptake and the effect this has on the overall BEPR performance.

(iv) Compare the BNR performance of the laboratory scale ENBNRAS system with that of a 'conventional' BNRAS system operated in parallel with equivalent design and operating parameters receiving the identical wastewater as influent.

CHAPTER 3

EXPERIMENTAL INVESTIGATION

3.1 EXPERIMENTAL SYSTEM SETUP

3.1.1 Main Biological Nutrient Removal Activated Sludge System

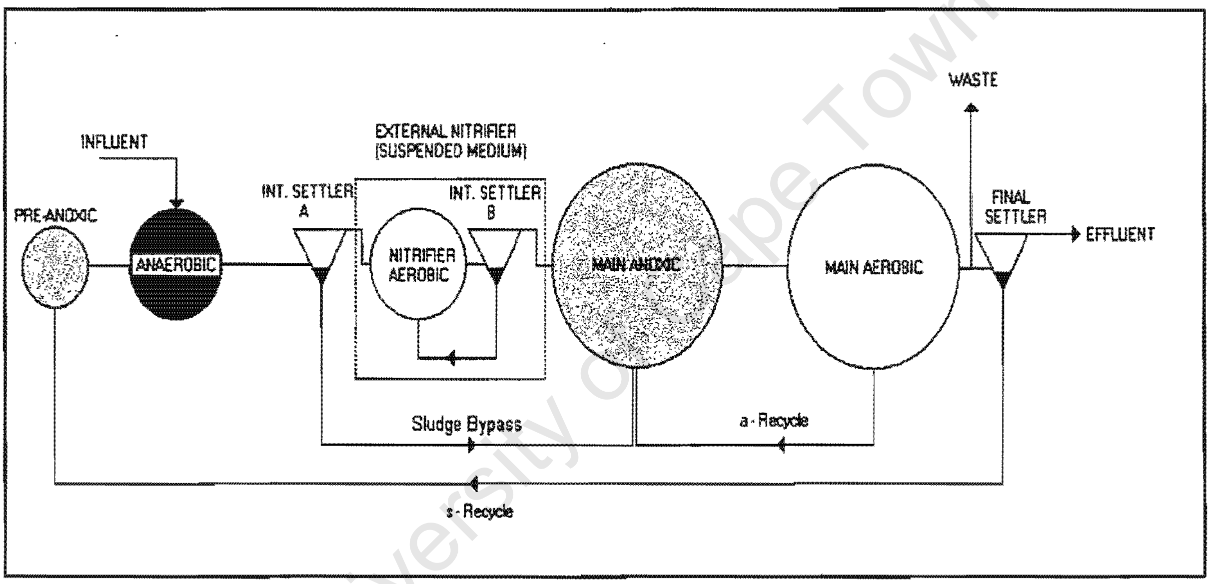

FIGURE 3.1 - Schematic layout of the laboratory scale external nitrification biological nutrient removal activated sludge (ENBNRAS) system.

The layout of the laboratory scale external nitrification biological nutrient removal activated sludge (ENBNRAS) system operated in this investigation is shown in Figure 3.1 and is similar to those operated in the two previous ENBNRAS research projects (Hu *et al.*, 1999 and Moodley *et al.*, 1999). Apart from differences in the reactor volumes and flows, the main modification implemented was in the setup of the external nitrification (EN) system, which will be discussed separately below. Because the setup of the EN system *per se* has no impact on the main system, it is permissible to compare the systems performance with that of the systems of Hu *et al.* (1999) and Moodley *et al.* (1999).

The activated sludge reactors and settling tanks of the ENBNRAS system are of the same kind that are usually used in laboratory investigations in the Water Research Laboratory of the University of Cape Town. They are made of clear acrylic plastic as described in detail by Clayton *et al.* (1989), mounted on a vertical wooden backboard with shelves, and the entire system is set above a 'drip tray' to facilitate the collection of any sludge spillages that may occur, to minimize the effect of these. The influent feed pipe, underflow (s) recycle, mixed liquor (a) recycle and the recycle from settling of the EN system sludge (internal settler B in Figure 3.1) to the nitrification reactor, were all connected to the same peristaltic pump, which was set to pump 20 l/d, or multiples thereof by utilizing more than one channel on the pump. The sludge bypass from internal settling tank A (in Figure 3.1) to the main anoxic reactor was via a separate peristaltic pump, pumping between 1 and 6.5 l/d, as required. Oxygen for the aerobic reactors was supplied in form of compressed air and the oxygen utilization rate (OUR) was measured with Yellow Springs dissolved oxygen (DO) probes and the automated DO controller/OUR meter of Randall *et al.* (1991).

The design parameters for the system are given in Table 3.1. The system was run in a temperature controlled laboratory at 20° C. The sludge age was set at 10 days by withdrawing 1/10th of the BNRAS system volume daily, appropriately reduced to take account of the sludge mass withdrawn for sampling. The sludge age in the EN system was not controlled - some sludge was wasted only when the sludge blanket level in the EN system settling tank (B in Figure 3.1) rose to more than half the settling tank column depth (~ 300 mm). In the BNRAS system, the initial unaerated mass fraction was 0.67, which was changed to 0.80 at day 195 of the 483-day investigation (see Table 3.1).

In the investigation of Hu *et al.* (1999), it was found that anoxic phosphorus uptake had not stabilized to a constant value at the end of the 250-day investigation. Accordingly in this investigation, in order to establish a steady state in the various biological processes, it was endeavoured to keep changes in the design and operating parameters to a minimum. However, in order to maintain proper functioning of the BNRAS system, it was necessary to make two changes, effectively resulting in three different configurations for the 10 days sludge age system (see Table 3.1). In the first change, the unaerated mass fraction was increased from 0.67 to 0.80 on day 187, by increasing the volume of the main anoxic reactor from 6.5 to 9 litres while simultaneously decreasing the volume of the main aerobic reactor from 6.5 to 4 litres. This was necessary because it was found that at high influent TKN/COD ratios (> 0.10 mgN/mgCOD) the system was not denitrifying adequately and too much nitrate was recycled to the anaerobic reactor, which adversely affected the phosphorus removal performance. In the second change on day 285, the a-recycle ratio was decreased from 2:1 (40 l/d) to 0:1 (0 l/d). This was done because by that time, the EN system was consistently nitrifying >90% of the FSA flowing into it, resulting in only small amounts of nitrate being produced in the main aerobic reactor. It was further suspected that the high a-recycle, which was forcing the sludge to alternate frequently between anoxic and aerobic conditions, was retarding and adversely affecting the anoxic phosphorus uptake.

Towards the end of the investigation period, on day 422, it was decided to increase the influent flow from 20 to 30 l/d so that the claimed benefit of increased capacity of the ENBNRAS system can be tested. This was done by increasing the speed of the main peristaltic pump to 30 l/d, thereby increasing the recycle flows by an equal amount and keeping the ratios constant. The combination of the increased influent flow and the associated increase in the recycle flows caused the internal settling tanks to fail hydraulically, and consequently it was decided to reduce the influent flow from 30 to 25 l/d and decrease the system sludge age from 10 to 8 days.

This was done on day 425, two days after the initial increase of the influent flow from 20 to 30 l/d. The system continued to perform exceptionally well at a sludge age of 8 days, and on day 471 it was decided to reduce the sludge age further - from 8 to 5 days. The experimental system was stopped approximately 2 sludge ages (11 days) after this on day 483.

TABLE 3.1 - ENBNRAS system design and operating parameters.

System Parameter	Config. 1	Config. 2	Config. 3	Config. 4**	Config. 5**
Days	1 to 186	187 to 284	285 to 421	422 to 470	471 to 483
Sewage Batches	1 to 13	14 to 20	21 to 30	31 to 33	34
No. of Days	186	98	137	49	13
Dates: From	22/02/99	04/09/99	09/12/99	18/04/00	08/06/00
To	03/09/99	08/12/99	17/04/00	07/06/00	18/06/00
Operating Parameters					
Influent Flow (l/d)	20	20	20	25	25
Sludge Age (d)	10	10	10	8	5
Waste (l/d)	2	2	2	2.5	4
Temperature (°C)	20	20	20	20	20
pH - Anaerobic Reactor	7.4 - 7.8	7.6 - 7.9	7.5 - 7.8	7.1 - 7.9	7.7 - 8.0
pH - Main Aerobic Reactor	7.2 - 7.8	7.7 - 8.1	7.7 - 8.2	7.4 - 8.4	7.7 - 8.0
D.O. Main Aerobic Reac. (mgO/l)	2 - 5	2 - 5	2 - 5	2 - 5	2 - 5
Reactor Vol. / Mass Frac.					
Total System Volume (l)	20	20	20	20	20
Pre-Anoxic Reactor (l)	1*	1*	1*	1*	1*
Anaerobic Reactor (l)	5	5	5	5	5
Main Anoxic Reactor (l)	6.5	9	9	9	9
Main Aerobic Reactor (l)	6.5	4	4	4	4
Total Aerobic Mass Fraction	0.33	0.20	0.20	0.20	0.20
Anoxic Mass Fraction	0.42	0.55	0.55	0.55	0.55
Anaerobic Mass Fraction	0.25	0.25	0.25	0.25	0.25
Total Unaerated Mass Fraction	0.67	0.80	0.80	0.80	0.80
Recycles					
s - Recycle (w.r.t influent flow)	1 : 1	1 : 1	1 : 1	1 : 1	1 : 1
a - Recycle (w.r.t influent flow)	2 : 1	2 : 1	0 : 1	0 : 1	0 : 1
Sludge Bypass (w.r.t influent flow)	0.12 : 1	0.30 : 1	0.32 : 1	0.34 : 1	0.37 : 1
External Nitrifier Parameters					
Sludge Age (d)	Very Long				
Waste (l/d)	As required to maintain reasonable sludge level in internal SST B.				
D.O (mgO/l)	>5				
Reactor Volume (l)	3				

*Actual volume, with sludge at double concentration. Effective volume at system sludge concentration = 2 litres.

** The results of Configurations 4 and 5 are not included in the average values discussed in Chapter 3.3 - Experimental Results. The results of Configurations 4 and 5 are discussed seperately in Chapter 3.4.

[shaded box] denotes changes made to the previous configuration.

3.1.2 External Nitrification System

In this investigation, the setup of the EN system differed from those used by Hu *et al.* (1999) and Moodley *et al.* (1999). Hu and Moodley used a combination of laboratory scale trickling filters (in the form of tall stone columns) to perform nitrification externally and/or dosing nitrate directly into the main anoxic reactor. The stone columns were used in the laboratory systems, to resemble as closely as possible the configurations of a full scale application. The laboratory scale stone columns proved to be difficult to run in the laboratory environment, primarily because of ammonia loading limitations and insect larvae infestations (*Psychoda*), resulting in low nitrification efficiency (< 50%). The larvae infestation itself and the attempts to control these infestations by flooding resulted in nitrifier biofilm being consumed by the larvae or scoured off the stones.

To overcome these problems with the stone column which adversely affected the performance of the BNRAS system (high effluent FSA without aerobic reactor nitrification or high nitrate discharge to the anaerobic reactor with aerobic reactor nitrification), it was decided to implement a suspended medium (activated sludge) EN system in this investigation. The details of this system setup are shown in Figure 3.2.

Once it became apparent that the suspended medium EN system produced consistent, eventually >90% nitrification, it was decided to stop nitrate dosing into the main anoxic reactor in order to evaluate the system performance and its consistency with as little 'outer system' interference as possible. Furthermore, initially it was found that the denitrification in the main anoxic reactor was very low, so nitrate dosing was not required in any event. Later in the investigation (around day 217) denitrification improved significantly, and so to increase the nitrate load on the main anoxic reactor, ammonia was dosed into the influent to raise the influent TKN/COD ratio of some sewage batches. These aspects are discussed in detail in the section on experimental system operation below.

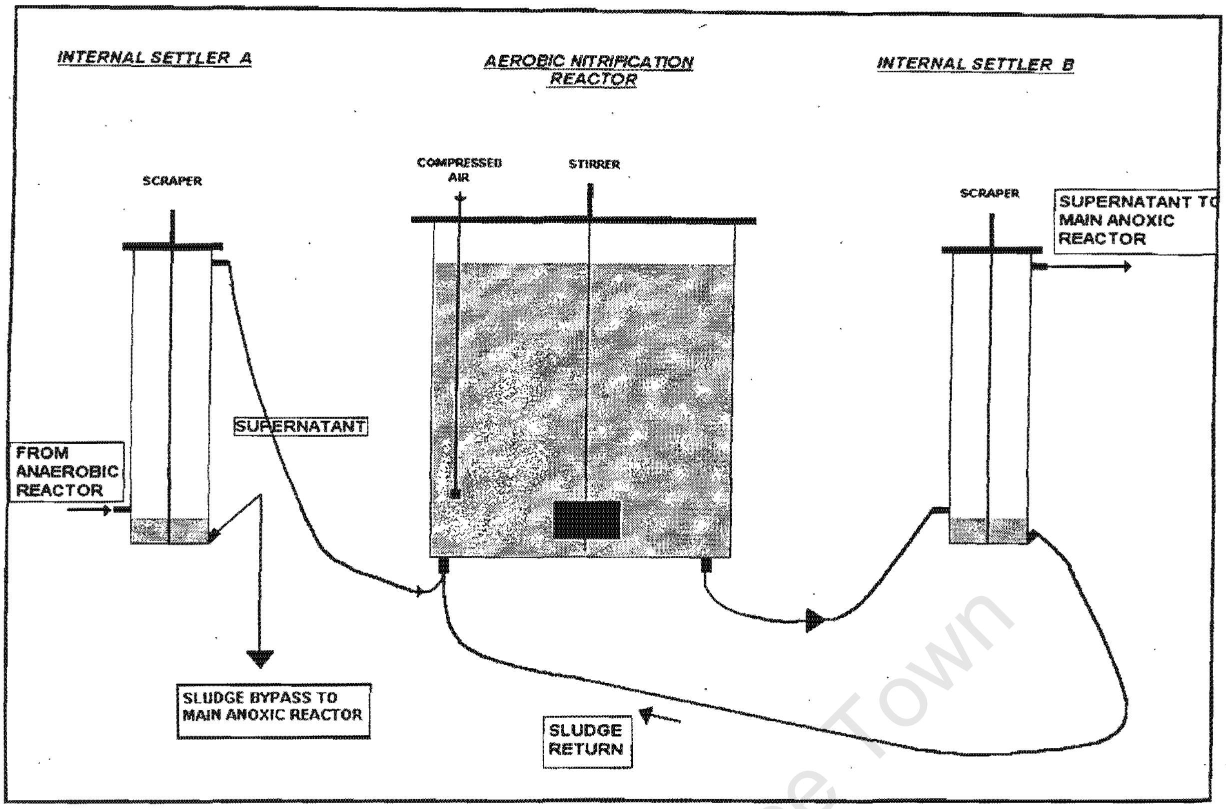

FIGURE 3.2 - Suspended activated sludge EN system.

3.2 EXPERIMENTAL SYSTEM OPERATION

The system was fed 20 litres per day (for Configurations 1, 2 and 3) and 25 litres per day (for Configurations 4 and 5) raw sewage originating from the Mitchells Plain WWTP. This sewage was collected in 2000 litre batches from the treatment works, after the coarse screens but before the fine screens, degritting and primary sedimentation. Each sewage batch lasted between 10 and 20 days. These sewage batches were stored in stainless steel tanks in a cold room with the temperature controlled at 4°C. 34 such sewage batches where fed to the system in the period from the 22/02/1999 to 18/06/2000. The raw sewage generally had a COD of between 1000 and 1300 mgCOD/l. For the system feed, a sample was drawn daily from the storage tanks (after thorough mixing) and diluted with tap water to a target value of 750 mg COD/l. A tablespoon of sodium hydrogen carbonate ($NaHCO_3$) was added as a buffer to control the pH to a value between 7.0 and 8.0. The total phosphorus (P) content of the diluted sewage was further augmented with approximately 10 mg P/l potassium di-hydrogen phosphate (KH_2PO_4) to avoid a situation of P limitation and to ensure an effluent total P concentration greater than 5 mgP/l. For some sewage batches the TKN concentration was augmented by addition of predetermined volumes of a 20g/l ammonium chloride (NH_4CL) stock solution - the exact volume depended on the desired TKN/COD ratio, see Table 3.2. A sample of this prepared influent was taken for analysis. The average sewage characteristic values for each batch of the influent fed to the system are given in detail in Table 3.2. The overall averages over the investigation of the influent COD, TKN and Total P were 732.0 mgCOD/l, 77.7 mgN/l and 25.4 mgP/l respectively. The required daily volume of the prepared influent was fed to the system at approximately 11:00 am daily. From sewage batch 13 to 30, a double volume of influent sewage was prepared daily, half of which was feed to a parallel conventional BNRAS UCT system for direct comparison of the ENBNRAS system performance. For details of this conventional system see Section 3.5 of this thesis and Vermande *et al.* (2000). The influent was stored in a fridge/freezer operating at a temperature of about 8°C. The influent bucket was equipped with a stirrer, to avoid the influent settling in the 24-hour feeding period. If at the end of the 24-hour feeding period any solids or sewage (usually <100 ml) were left in the influent bucket, these were collected and poured directly into the anaerobic reactor. The entire daily waste sludge volume was drawn from the main aerobic reactor and the mixed liquor drawn off was replaced by system effluent so that the main aerobic reactor remained at its set volume. The volume of mixed liquor wasted was appropriately adjusted for the sludge volume removed in the sampling process.

TABLE 3.2 - Influent sewage characteristics: Batch averages for sewage batches 1 to 34.

Batch	Day No.	Days	COD *mgCOD/l*	RBCOD *mgCOD/l*	TKN/COD Ratio	TKN *mgN/l*	FSA *mgN/l*	NH_4CL added *as mgN/l*	Total P *mgP/l*
1	1 - 11	11	757.3	158.6	0.076	58.7	40.0	-	22.1
2	12 - 15	4	Bad Batch						
3	16 - 25	10	605.8	117.8	0.142	86.0	62.9	-	19.7
4	26 - 38	13	787.9	158.5	0.113	88.0	66.8	-	23.3
5	39 - 54	16	609.8	129.3	0.120	73.1	56.9	-	21.3
6	55 - 67	13	746.7	171.7	0.111	81.6	62.5	-	29.0
7	68 - 82	15	694.7	98.2	0.084	58.1	43.9	-	23.5
8	83 - 98	16	766.1	129.0	0.103	78.7	61.5	-	26.0
9	99 - 102	4	Bad Batch						
10	103 - 134	32	799.4	124.0	0.079	63.4	48.1	-	23.8
11	135 - 152	18	783.1	111.8	0.110	87.9	72.8	-	24.3
12	153 - 166	14	764.7	127.9	0.110	85.6	67.5	-	29.8
13	167 - 186	20	784.6	105.4	0.110	84.6	71.2	45.0	25.6
14	187 - 203	17	715.4	129.2	0.113	80.4	60.8	-	23.4
15	204 - 216	13	727.7	150.1	0.126	92.0	75.1	-	27.2
16	217 - 231	15	758.8	161.1	0.112	85.2	68.0	-	26.7
17	232 - 245	14	664.3	119.5	0.101	66.9	52.6	-	24.3
18	246 - 259	14	757.8	165.1	0.091	69.0	53.0	-	28.1
19	260 - 271	12	684.9	157.4	0.125	85.8	69.6	20.0	21.5
20	272 - 284	13	760.9	140.7	0.093	70.5	53.9	-	27.0
21	285 - 296	12	749.1	157.0	0.090	67.3	52.0	-	24.8
22	297 - 311	15	718.0	144.1	0.113	80.9	65.6	10.0	25.0
23	312 - 327	16	722.3	138.5	0.120	86.6	71.0	-	23.3
24	328 - 341	14	713.8	136.9	0.125	89.0	73.1	-	24.8
25	342 - 355	14	759.7	182.7	0.086	65.3	52.1	-	29.8
26	356 - 368	13	708.8	137.4	0.115	81.4	65.0	10.0	29.9
27	369 - 382	14	711.2	158.8	0.102	72.6	59.7	15.0	25.1
28	383 - 397	15	734.1	136.0	0.123	90.1	72.7	18.0	25.5
29	398 - 407	10	738.1	144.9	0.096	71.0	59.0	20.0	26.0
30	408 - 421	14	747.8	156.5	0.104	77.7	61.9	10.0	28.3
31	422 - 438	17	731.6	122.15	0.088	64.33	50.0	-	25.1
32	439 - 456	18	779.8	150.3	0.103	79.9	64.0	12.0	26.3
33	457 - 470	14							
34	471 - 483	13	709.2	154.6	0.120	87.52	71.84	-	26.0
Average	-	**15**	**732.0**	**141.1**	**0.107**	**77.7**	**61.5**	-	**25.4**

When necessary, the system was dismantled and cleaned. This involved stopping the pumps, draining the activated sludge from the system, and dismantling all the reactors. The activated sludge was passed through a fine mesh strainer to remove large solids and worms from the bulk liquid. This was done because these solids and worms were the main cause of blockages in the pipes and the subsequent sludge spillages that occurred. The reactors and stirrers were washed and all the piping cleaned. The cleaning process did influence the system because of inevitable VSS loss, and so it was carried out only when an increase in blockages or a proliferation of worms was noticed.

3.2.1 Difficulties and Problems in Operation

During the beginning of the investigation (sewage batch 1 to 6) some difficulties in the system operation were encountered. Blockages and sludge spillages as well as component breakdowns occurred. The problem areas in the mechanics of the system were identified and subsequent modifications ensured that the re-occurrence of similar problems was minimized. Furthermore, there were two 'bad' batches of sewage. The first bad sewage batch, batch 2, contained a noticeable amount of activated sludge. This occurs when there is a problem at the Mitchells Plain WWTP and sludge is recycled back to the inlet works and mixed with the influent. This sewage batch was discarded and no further effect on the system was noticed.The second bad batch of sewage, batch 9, was toxic. On feeding this sewage batch, nitrification ceased in all systems operating in the laboratory. This sewage batch was immediately discarded and a new one fed, but the effects of sewage batch 9 were noticed until the end of sewage batch 15. Complete nitrification did not return until the end of sewage batch 12. Instead of producing nitrate, nitrite was produced in large quantities and this led to the conclusion that the toxic batch inhibited the nitrate producers (nitrite oxidizers) whilst leaving the nitrite producers (ammonia oxidizers) largely unaffected. Later it was found that denitrification was also adversely affected by the toxic sewage batch and poor denitrification performance lasted until the end of sewage batch 15. The toxic sewage batch 9 was fed at the beginning of June 1999, just before winter. Hu *et al.* (1999), Moodley *et al.* (1999) and Mellin *et al.* (1995) reported toxic sewage batches around the same time, being just before winter. This indicates that some phenomenon occurs in the sewage (at the Mitchell's Plain WWTP) around the beginning of winter that has a toxic effect on the laboratory scale systems.

3.2.2 System Performance Monitoring and Data Acquisition

In order to monitor the system performance effectively, sampling was done on a virtually daily basis. No samples were drawn under the following conditions:

- After sludge spillages occurred, resulting in sludge loss.
- For two days after a new batch of sewage was fed, to allow the organisms to adapt to the new feed.
- The last day of a sewage batch because it was noticed that this last sewage of the batch usually had very low RBCOD concentrations.

Table 3.3 shows the sampling positions in the system and the parameters measured on these samples.

TABLE 3.3 - Sampling positions and parameter measurement.

Test	COD	TKN	FSA	NO_3	NO_2	Tot. P	OUR	DSVI	VSS/TSS
Influent	✪⊡	✪	✪			✪			
Pre Anoxic				✙	✙	✙			✓
Anaerobic				✙	✙	✙			
Int. Set. A	✪'		✪'	✙	✙	✙			
Int. Set. B	✪'		✪'	✙	✙	✙			
Main Anoxic				✙	✙	✙			
Main Aerobic	◆	◆		✙	✙	✙	✓	✓	✓
Final Effluent	✪✙	✪✙	✪	✙	✙	✪✙			

✪ = Unfiltered Sample
✪' = Unfiltered Supernatant
⊡ = Floc Filtered Sample
(1 litre sample subjected to 10 ml 0.25M Aluminium Sulphate flocculation and allowed to settle for a minimum of 10 minutes).
✙ = Filtered Sample
(Filtered through Schleicher&Schuell 0.45 μm glassfibre filter membrane)
◆ = Unfiltered, Macerated Mixed Liquor Sample
✓ = Measurement Taken, Filtration Not Applicable

The diluted sludge volume index (DSVI) was measured on 500 ml mixed liquor drawn from the main aerobic reactor, diluted to 1 litre using system effluent. VSS/TSS were measured by separating the solids from the liquid with a centrifuge, drying the sludge pellet at 105°C for 24 hours and then incinerating it at 600°C for 20 minutes (Standard Methods, 1985). The pH was measured using pH meter No. HI9023 from *HANNA INSTRUMENTS*. COD, TKN and FSA were measured by the methods laid out in Standard Methods (1985). Nitrate and nitrite was measured by using the Technicon Auto Analyser Industrial Method No. 33.69W. Total phosphorus was measured using sulphuric acid / potassium persulphate digestion at 100°C followed by ammonium molybdate / vanadate colour development for ortho-phosphate (Standard Methods, Method 424C III). From day 1 to 92, an error occurred in the phosphate measurements for the anaerobic and main aerobic reactors. In this period, the pH readings for the anaerobic and main aerobic reactors were taken directly in the jars containing the samples drawn from these reactors. The buffer solution in which the pH probe was stored and calibrated contained very high concentrations of phosphate which contaminated the samples with respect to the total P test done subsequently. Whilst the erroneous P measurements were noticed much earlier, the cause of the error was only found after a rigorous investigation into all testing procedures involved. After the error was found, the pH readings were taken directly in the reactors concerned and no longer in the sample jars. The affected readings have been excluded from the data analysis.

3.3 EXPERIMENTAL RESULTS

Daily results are listed in Appendix A. Tables 3.4a, b and c list the sewage batch averages of all measured parameters for sewage batches 1 to 30, as measured in accordance with Table 3.3 (Sampling Position and Parameter Measurement). The sewage batch periods were chosen to calculate the averages, because the influent TKN and TP concentrations varied from sewage batch to sewage batch. The overall averages of all 30 sewage batch average values for each parameter were also calculated to provide an indication of the average long term performance of the system. The sewage batch average values provide the basis for all further calculations, deductions and discussions on the performance of the system at 10 days sludge age and approximately 750 mgCOD/l load. The average values for sewage batches 31, 32, 33 (Configuration 4 - 25 litre influent flow and 8 days sludge age) and sewage batch 34 (Configuration 5 - 25 litre influent flow and 5 days sludge age) are discussed separately in Section 3.4.

3.3.1 Carbonaceous Material Removal

3.3.1.1 COD mass balance

In the COD mass balance, the COD mass (i) consumed in the external nitrification (EN) system, (ii) utilized in denitrification of nitrate (NO_3) and nitrite (NO_2), (iii) e^- passed to oxygen, (iv) in the wasted sludge and (v) in the effluent is reconciled with the influent COD mass (for details, see Appendix B). The closer the COD balance is to a target value of 100% (i.e. all the influent COD mass being accounted for), the more reliable the experimental data is deemed to be. Apart from being a measure of reliability of the data concerned, the COD mass balance also gives an indication of what fraction of the influent COD mass is consumed in the EN system (i.e. lost to the main system), utilized in the denitrification of NO_X ($NO_2 + NO_3$) in the anoxic and pre-anoxic reactors and what fraction is being passed to Oxygen as an electron acceptor in the main aerobic reactor. The COD utilized in the EN system is important because this COD is not available for the BNR processes in the main system. The COD utilised in the denitrification process is of interest not only because of the nitrogen removal *per se*, but it also represents the fraction of COD that does not require oxygen in the main aerobic reactor, viz. the saving in the oxygen supply to the main aerobic reactor.

TABLE 3.4a - Sewage batch averages of measured COD and TKN parameters for sewage batches 1 to 30.

Sewage Batch	mgCOD/l							mgN/l								
	COD							TKN				FSA				TKN/COD Ratio
	Influent	Floc Filt. Infl.	Int. Set. A	Int. Set. B	Aerobic M.L	Unfilt. Effl.	Filt. Effl.	Influent	Aerobic M.L	Unfilt. Effl.	Filt. Effl.	Influent	Int. Set. A	Int. Set. B	Unfilt. Effl.	Influent
1	757.3	200.0	106.0	78.6	2128.6	41.4	41.4	58.7	177.1	4.6	3.3	40.0	16.7	7.0	3.1	0.076
2	Bad Batch															
3	Bad Batch															
4	787.9	211.1	213.2	73.5	1810.6	54.2	52.6	88.0	108.2	9.5	8.2	66.8	32.8	21.9	6.2	0.113
5	609.8	170.8	160.3	66.3	1580.2	50.1	41.4	73.1	115.0	5.8	3.4	56.9	26.4	7.7	2.9	0.120
6	746.7	218.9	212.4	99.5	1890.0	59.0	47.2	81.6	112.6	4.9	4.3	62.5	27.4	8.4	2.9	0.111
7	694.7	143.5	166.7	63.0	1700.7	46.5	45.3	58.1	118.4	3.7	3.1	43.9	20.6	2.6	2.2	0.084
8	766.1	185.5	188.9	62.2	1324.8	59.3	56.4	78.7	106.0	5.0	4.0	61.5	29.0	3.1	3.2	0.103
9	Bad Batch															
10	799.4	175.7	177.8	103.5	1229.8	62.2	51.7	63.4	90.4	7.9	7.2	48.1	22.4	10.0	6.0	0.079
11	783.1	166.5	146.3	102.4	1838.6	79.2	54.7	87.9	117.4	4.9	3.4	72.8	31.4	9.8	2.4	0.114
12	764.2	169.0	113.6	70.2	1679.4	62.5	40.6	85.5	117.6	5.7	4.9	68.0	29.4	3.3	4.2	0.112
13	780.9	154.1	134.5	68.4	1745.6	57.9	45.1	81.8	108.4	4.4	3.8	68.4	29.5	2.9	2.8	0.105
14	715.4	163.3	140.6	46.1	1551.9	39.2	34.1	80.4	97.5	4.4	3.6	60.8	27.6	3.0	3.0	0.113
15	727.7	195.6	153.4	56.9	1403.3	52.8	45.4	92.0	97.4	5.7	4.9	75.1	33.6	3.4	4.3	0.126
16	758.8	195.9	157.8	47.1	2000.3	42.6	34.8	85.2	126.7	5.1	4.5	68.0	32.4	3.5	3.5	0.112
17	664.3	159.9	135.4	57.2	2046.3	49.5	40.5	66.9	134.9	4.9	4.0	52.6	25.6	3.1	3.4	0.101
18	757.8	200.6	152.4	53.8	1912.1	44.2	35.5	69.0	129.2	4.7	3.9	53.0	25.3	3.3	3.5	0.091
19	684.9	202.9	129.5	63.5	2122.0	48.9	45.5	85.8	144.2	5.3	4.6	69.6	34.1	3.4	3.6	0.125
20	760.9	176.2	136.6	51.5	2244.7	43.7	35.5	70.5	146.8	4.7	4.2	53.9	25.9	3.3	3.7	0.093
21	749.1	197.6	132.3	59.4	2328.8	45.3	40.6	67.3	139.8	4.7	4.2	52.0	25.6	3.4	3.9	0.090
22	718.0	181.6	142.5	62.2	2140.4	42.8	37.4	80.9	143.6	4.7	4.2	65.6	31.6	3.6	3.7	0.113
23	722.3	173.5	128.8	51.8	1675.8	41.3	35.0	86.6	127.8	5.2	4.5	71.0	33.8	3.4	3.8	0.120
24	713.8	176.7	111.7	55.4	2137.6	47.1	39.8	89.0	148.4	5.5	4.7	73.1	34.2	3.6	4.3	0.125
25	759.7	222.6	121.2	48.1	2310.5	46.3	39.9	65.3	152.9	5.1	4.3	52.1	24.1	3.5	3.8	0.086
26	708.8	174.8	131.4	42.9	2481.0	43.1	37.5	81.4	172.4	4.9	4.2	65.0	30.9	3.3	3.6	0.115
27	711.2	195.5	129.6	51.3	2716.2	48.7	36.7	72.6	161.4	4.5	3.9	59.7	26.4	3.1	3.4	0.102
28	734.1	174.6	123.0	53.3	2472.6	50.2	38.6	90.1	145.9	4.5	3.8	72.7	33.1	3.1	3.3	0.123
29	738.1	181.2	132.7	53.8	2232.9	50.9	36.2	71.0	150.8	4.9	4.2	59.0	26.9	3.2	3.7	0.096
30	747.8	196.0	119.1	71.1	2226.5	55.9	39.5	77.7	141.6	4.0	3.3	61.9	28.4	2.3	2.4	0.104
Overall	735.7	183.8	144.4	63.4	1960.4	50.6	41.8	77.3	130.8	5.2	4.3	61.3	28.3	4.9	3.6	0.106
*	UF	FF	UF	UF	UF	UF	F	UF	UF	UF	F	UF	UF	UF	UF	UF

TABLE 3.4b - Sewage batch averages of measured suspended solids, OUR, DSVI and pH for sewage batches 1 to 30.

Sewage	mg SS/l								mgO/l/h	ml/g		
Batch	TSS	VSS	ISS[1]	TSS	VSS	ISS[1]	COD/VSS Ratio[2]	TKN/VSS Ratio[2]	OUR	DSVI	pH	
	PreANO	PreANO	PreANO	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Anaerobic	Aerobic
1	4224.6	3178.6	1046.0	1981.1	1522.9	458.3	1.38	0.13	30.10	130.45	7.54	7.48
2	Bad Batch											
3	Bad Batch											
4	3291.2	2772.0	519.2	1571.6	1329.6	242.0	1.32	0.08	34.1	96.8	7.58	7.45
5	2646.6	2238.3	408.3	1380.9	1186.9	194.0	1.30	0.10	22.9	120.9	7.58	7.52
6	3140.0	2628.8	511.2	1615.2	1376.4	238.8	1.35	0.08	26.6	122.2	7.43	7.50
7	2946.2	2343.0	603.2	1656.2	1355.0	301.2	1.23	0.09	20.7	115.3	7.63	7.59
8	2296.3	1921.3	448.0	1252.6	1032.0	220.6	1.23	0.10	20.8	109.7	7.53	7.66
9	Bad Batch											
10	1967.7	1646.0	321.7	988.1	835.9	152.3	1.41	0.11	16.8	129.4	7.45	7.69
11	2677.5	2171.7	505.8	1419.1	1159.4	259.7	1.54	0.10	21.9	119.5	6.30	6.37
12	2906.5	2425.0	481.5	1531.8	1285.7	246.0	1.28	0.09	15.8	116.7	7.57	7.43
13	2842.0	2372.4	469.6	1390.0	1171.4	218.6	1.47	0.09	13.8	126.0	7.74	7.75
14	2636.0	2216.2	419.8	1339.2	1108.2	231.0	1.37	0.09	14.6	131.9	7.67	7.76
15	2315.2	1888.4	426.8	1155.6	956.4	199.2	1.42	0.10	14.2	154.2	7.85	7.81
16	3044.0	2502.2	541.8	1628.6	1340.2	288.4	1.47	0.10	20.3	112.7	7.62	7.92
17	3353.1	2761.1	592.0	1626.2	1355.1	271.1	1.48	0.10	23.4	99.0	7.80	7.98
18	3066.5	2535.5	531.0	1547.0	1315.3	231.7	1.42	0.10	17.8	87.6	7.68	8.04
19	2978.3	2450.0	528.3	1699.4	1425.1	274.3	1.46	0.10	18.2	86.0	7.70	7.78
20	3621.3	2981.8	639.6	1844.7	1548.7	296.0	1.43	0.10	19.4	91.9	7.65	8.03
21	3818.0	3084.3	733.7	1897.1	1552.0	345.1	1.47	0.09	18.8	88.2	7.61	8.05
22	3375.8	2727.6	648.2	1786.8	1488.4	298.4	1.41	0.10	17.0	93.9	7.50	7.70
23	2499.1	2050.9	448.2	1392.4	1172.2	220.2	1.40	0.11	17.0	98.4	7.71	7.86
24	3453.1	2797.3	655.8	1834.7	1514.0	320.7	1.39	0.10	22.8	101.5	7.72	7.87
25	3448.9	2841.3	607.6	1939.1	1607.8	331.3	1.41	0.10	19.6	106.4	7.57	8.03
26	4045.8	3318.4	727.3	2153.6	1777.1	376.4	1.37	0.10	19.9	94.7	7.52	8.03
27	3422.8	2803.5	619.3	2253.5	1844.0	409.5	1.45	0.09	16.1	89.0	7.65	8.12
28	3187.3	2597.6	589.8	2034.0	1677.3	356.7	1.45	0.09	17.8	94.9	7.59	7.87
29	3459.4	2804.3	655.1	1837.4	1497.7	339.7	1.47	0.10	18.5	97.2	7.52	7.98
30	3356.0	2709.1	646.9	1861.4	1516.0	345.4	1.44	0.09	19.4	91.3	7.64	8.03
Overall	3111.8	2546.9	567.6	1652.5	1368.5	284.0	1.40	0.10	19.9	107.6	7.57	7.75

1 ISS calculated from TSS - VSS.
2 Calculated from unfiltered aerobic reactor COD and TKN concentrations divided by the VSS.

TABLE 3.4c - Sewage batch averages for measured nitrate, nitrite and P concentrations for sewage batches 1 to 30 - all concentrations measured on glassfibre filtered samples.

Sewage Batch	mgN/l														mgP/l								
	Nitrite							Nitrate							Phosphates								
	PreANO	Anaerobic	Int. SET A	Int. SET B	Anoxic	Aerobic	Filt. Effl.	PreANO	Anaerobic	Int. SET A	Int. SET B	Anoxic	Aerobic	Filt. Effl.	Influent	PreANO	Anaerobic	Int. SET A	Int. SET B	Anoxic	Aerobic	Unfilt. Effl.	Filt. Effl.
1	0.2	0.1	0.1	2.3	0.4	0.5	0.3	2.2	0.5	0.2	11.3	2.5	4.8	4.2	22.1	9.2		27.9	31.0	15.2		7.3	6.8
2	Bad Batch																						
3	Bad Batch																						
4	1.9	0.1	0.1	1.0	1.8	1.2	0.9	6.2	0.2	0.2	12.6	6.7	11.3	12.9	23.3	14.0		26.6	26.3	18.4		15.3	15.4
5	1.1	0.1	0.1	2.2	1.5	1.1	1.0	10.1	0.5	0.2	15.5	11.9	13.9	14.4	21.3	16.3		19.6	22.5	17.7		18.0	17.5
6	0.0	0.1	0.1	1.0	2.8	3.5	2.5	1.1	0.3	0.2	15.2	2.9	6.1	8.0	29.0	15.3		29.2	33.7	21.2		15.1	15.4
7	0.5	0.1	0.1	0.5	2.3	0.9	0.7	1.7	0.2	0.2	16.1	2.8	4.7	4.9	23.5	11.2		27.2	31.8	17.1		12.5	12.3
8	3.5	0.2	0.1	1.5	3.4	2.9	2.3	4.8	0.4	0.2	20.9	9.0	10.1	11.0	26.0	17.3		27.8	31.0	21.6		20.3	19.4
9	Bad Batch																						
10	0.2	0.0	0.1	7.0	2.0	2.2	1.6	0.8	0.1	0.1	1.8	0.3	1.2	1.4	23.8	14.1	23.2	25.1	22.3	17.4	14.4	14.7	14.2
11	4.0	0.2	0.3	20.3	9.8	9.1	7.9	3.1	0.2	0.2	4.8	2.8	6.4	6.8	24.3	15.3	23.7	28.0	30.7	21.7	17.8	18.4	17.3
12	0.3	0.0	0.1	0.9	0.5	0.3	0.5	8.0	0.3	0.3	21.8	11.9	11.6	11.3	29.5	13.6	24.9	28.2	30.9	20.7	15.8	16.5	15.6
13	0.5	0.1	0.0	0.2	0.6	0.3	0.3	9.6	0.3	0.3	26.2	14.0	14.6	13.7	25.6	16.4	19.4	21.6	24.0	19.3	17.2	17.7	17.1
14	0.3	0.0	0.0	0.2	0.6	0.4	0.3	5.5	0.2	0.2	18.5	9.1	9.6	9.2	23.4	13.0	22.0	25.3	27.4	18.2	15.6	15.7	15.5
15	0.4	0.0	0.0	0.1	0.5	0.5	0.5	10.3	0.2	0.3	21.7	13.0	13.5	12.5	27.2	14.9	22.2	25.6	27.8	19.4	17.4	16.2	15.8
16	0.3	0.0	0.1	0.1	1.1	0.7	0.6	0.7	0.1	0.2	21.8	4.7	5.4	5.0	26.7	14.4	29.3	31.3	32.8	20.0	16.3	16.8	16.4
17	0.6	0.0	0.0	0.1	1.7	0.8	0.5	0.8	0.1	0.1	14.3	3.8	5.0	4.3	24.3	14.1	25.5	27.2	30.6	20.1	17.3	17.0	16.8
18	0.0	0.0	0.0	0.2	0.6	0.3	0.2	0.1	0.1	0.2	13.0	0.3	1.2	1.2	28.1	18.2	31.5	33.0	34.6	21.5	18.1	18.3	18.0
19	0.7	0.0	0.0	0.3	1.2	1.0	0.8	3.1	0.1	0.2	20.1	7.4	7.6	7.7	21.5	13.4	21.2	24.2	27.6	18.3	16.1	15.6	15.3
20	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.0	0.1	0.1	14.7	0.1	0.4	0.5	27.0	17.9	28.8	30.8	33.1	20.9	17.5	17.3	16.7
21	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.1	12.9	0.1	0.6	0.4	24.8	16.1	26.5	27.9	31.1	22.2	15.4	15.3	14.9
22	0.3	0.0	0.0	0.1	2.6	1.1	1.0	0.2	0.1	0.2	18.6	1.9	3.7	3.3	25.0	14.7	26.6	28.8	31.8	22.2	17.0	16.1	15.7
23	0.6	0.0	0.0	0.2	1.3	0.9	0.5	3.2	0.1	0.2	23.1	4.5	6.9	7.2.	23.3	15.4	24.4	25.8	27.9	20.5	17.1	17.3	16.9
24	0.6	0.0	0.0	0.0	1.9	0.7	0.6	2.3	0.1	0.1	19.5	5.2	6.4	5.6	24.8	14.1	24.9	27.3	30.9	21.2	16.2	15.4	15.0
25	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	11.2	0.1	0.8	0.8	29.8	21.0	34.3	36.4	39.2	28.0	18.9	19.0	18.9
26	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	17.9	0.1	1.5	1.4	29.9	17.5	36.8	39.1	41.5	24.6	16.2	15.8	15.6
27	0.0	0.0	0.0	0.3	0.4	0.1	0.1	0.0	0.1	0.2	16.7	0.1	0.8	0.8	25.1	16.5	29.1	32.1	35.6	21.9	16.1	16.5	16.1
28	0.6	0.1	0.0	0.1	2.1	1.2	1.2	1.3	0.1	0.3	27.3	1.9	4.3	4.5	25.5	13.8	29.6	31.6	34.9	20.4	15.8	15.5	15.2
29	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.2	17.5	0.1	1.5	1.2	26.0	14.7	30.6	32.4	35.5	21.6	14.9	15.0	14.6
30	0.1	0.0	0.0	0.1	0.4	0.2	0.2	0.1	0.1	0.1	20.8	1.3	3.3	2.8	28.3	13.7	30.8	32.5	36.1	23.5	15.7	15.1	14.7
Overall	0.6	0.1	0.1	1.4	1.5	1.1	0.9	2.8	0.2	0.2	16.9	4.4	5.8	5.8	25.5	15.0	26.9	28.6	31.2	20.5	16.5	16.1	15.7

The COD mass balances (including their components) and percentage COD removals achieved by the system, for sewage batches 1 to 30, are listed in Table 3.5 and Figure 3.3 shows the COD mass balances obtained for the 30 sewage batches graphically. Detailed results are listed in

TABLE 3.5 - COD mass balances for sewage batches 1 to 30.

Average of Batch	Influent COD mgCOD/d	MOC mgO/d	Denitrification Recovery mgCOD/d	COD used Ext. Nit. mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	COD out mgCOD/d	% Recovery	% COD Removal
1	15200	4049	1937	1495	4380	828	12690	83.6	94.6
2	Bad Batch								
3	Bad Batch								
4	14562	3351	2154	5327	3434	950	15215	104.6	93.5
5	11789	2928	1736	3330	3167	905	12067	101.6	92.3
6	14935	2606	2551	4327	3780	1063	14326	96.6	92.9
7	13894	2516	2212	3975	3401	837	12942	93.3	94.0
8	15322	2567	2425	4858	2650	1068	13569	88.9	93.0
9	Bad Batch								
10	15988	2232	793	2999	2460	1120	9603	60.2	93.0
11	15662	2278	2198	1821	3677	1426	11400	74.5	90.9
12	15284	2618	1763	1553	3359	1125	10418	68.4	92.6
13	15618	2029	2171	2352	3491	1042	11086	71.6	93.3
Config.1	*14825*	*2717*	*1994*	*3204*	*3380*	*1036*	*12332*	*84.3*	*93.0*
14	14308	1722	1574	3311	3104	706	10417	73.3	95.1
15	14553	1179	1642	3379	2807	950	9956	68.4	93.5
16	15176	1829	2103	3719	4001	767	12419	81.9	94.9
17	13286	2073	1564	2627	4093	891	11248	84.8	93.3
18	15155	1463	1477	3311	3824	795	10871	72.3	94.8
19	13699	1710	1687	2215	4244	881	10736	78.6	93.6
20	15218	1741	1499	2859	4489	786	11375	75.0	94.8
Config.2	*14485*	*1674*	*1649*	*3060*	*3794*	*825*	*11003*	*76.3*	*94.3*
21	14981	1661	1305	2448	4658	815	10886	72.8	94.6
22	14360	1524	1963	2696	4281	771	11235	78.4	94.6
23	14445	1258	2237	2588	3352	744	10178	70.8	94.8
24	14275	2123	1872	1891	4275	849	11010	78.2	94.1
25	15193	1757	1126	2456	4621	833	10794	71.1	94.5
26	14175	1662	1829	2976	4962	776	12206	86.8	94.5
27	14224	1471	1683	2630	5432	877	12094	85.4	93.8
28	14682	1389	2834	2354	4945	903	12425	84.8	93.9
29	14763	1513	1791	2666	4466	915	11351	77.0	93.8
30	14956	1521	2120	1642	4453	1006	10742	71.8	93.3
Config.3	*14606*	*1588*	*1876*	*2435*	*4544*	*849*	*11292*	*77.7*	*94.2*
Overall	**14656**	**2028**	**1861**	**2882**	**3919**	**912**	**11602**	**79.8**	**93.8**

Appendix B. As can be seen from Table 3.5, an average COD mass balance of 79.8% was attained over the 30 sewage batches. The highest and lowest COD mass balances were 104.6% (sewage batch 4) and 60.2% (sewage batch 10) respectively. The lowest COD mass balance was immediately following sewage batch 9, which was a toxic sewage batch. The system had not recuperated completely from this toxic sewage batch and hence the very poor COD mass balance was obtained for sewage batch 10. From the averages for the Configurations 1, 2 and 3, there is no evidence that any of the configurations had a noticeable positive or negative effect on the COD mass balances. Configuration 1 has an average COD mass balance of 84.3%, which is higher than that for Configurations 2 and 3 (76.3 and 77.7% respectively). However, the period in which

Configuration 1 was operated included sewage batches 1 to 8, and Figure 3.3 shows that the COD mass balances in the beginning of the investigation (sewage batches 1 to 8) were good, albeit steadily decreasing. This fact will have contributed to the higher average for Configuration 1, rather than the configuration itself. After the feeding of the toxic sewage batch (sewage batch 9), the COD mass balances decreased to a slightly lower level and never recovered completely to the level of the first eight sewage batches.

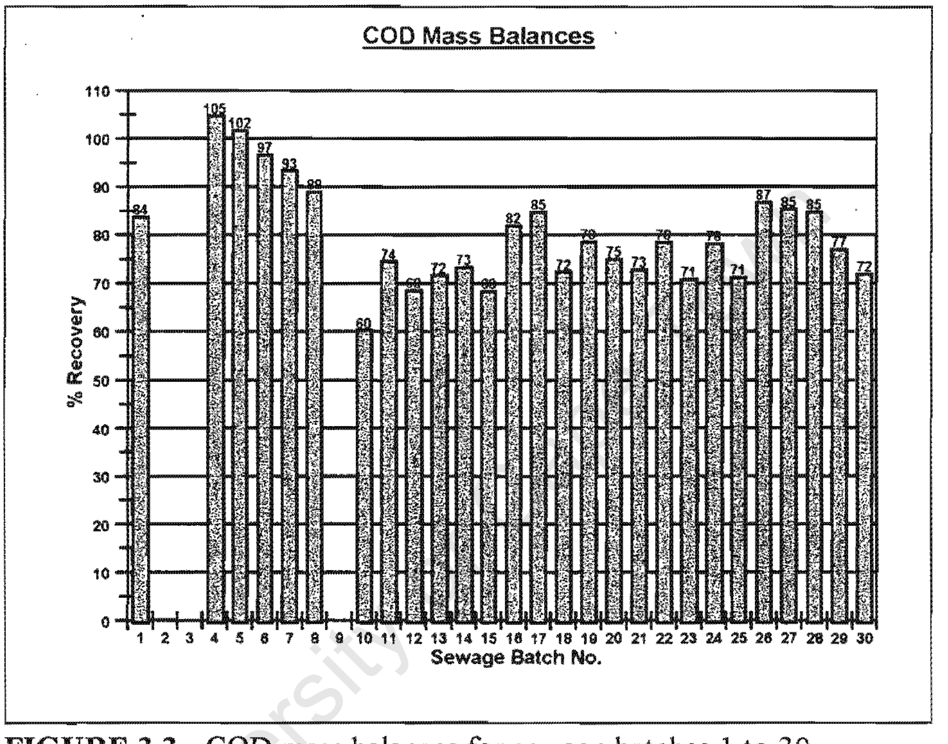

FIGURE 3.3 - COD mass balances for sewage batches 1 to 30.

In previous investigations on biological nutrient removal activated sludge systems (BNRAS systems) and on ENBNRAS systems it was found that generally the COD mass balances were around 80 to 90% (Table 3.5a), see Ekama and Wentzel *et al.* (1999):

TABLE 3.5a - COD mass balances obtained for previous investigations.

Researcher	System	COD Mass Balance
Pilson *et al.* (1995)	Conventional BNRAS system	84%
Sneyders *et al.* (1998)	Conventional BNRAS system	90%
Mellin *et al.* (1998)	Conventional BNRAS system	84%
Hu *et al.* (1999)	ENBNRAS system	90%
Moodley *et al.* (1999)	ENBNRAS system	80%

All the investigations show COD mass balances significantly below 100%, between 80 and 90%. The average of approximately 80% for this investigation is lower than all of the aforementioned and equal to that of Moodley *et al.* (1999). However, this does not mean that the results are necessarily less reliable. Moodley *et al.* (1999) contributed the low COD balance in their investigation to the frequent sludge spillages that occurred. In this investigation very few sludge spillages occurred, and most of those that did occur happened in the beginning of the investigation (Configuration 1) when the COD balances were better. When it became clear that the COD mass balances being obtained were low, a thorough investigation into the sampling and analytical testing procedures was conducted, but nothing was found that could have caused the low COD mass balances. Furthermore, had there been any errors in the testing procedures, these would have become apparent in the COD/VSS (f_{cv}) and TKN/VSS (f) ratios obtained in this investigation. The overall averages for these were 1.40 and 0.10 respectively (see Table 4b) and these are very close to the expected values of 1.48 and 0.10 respectively (WRC, 1984).

It seems that there are biological processes that occur in the BNRAS and ENBNRAS systems with a high unaerated mass fraction, which consume a fraction of the influent COD and are not taken into account in the COD mass balance. What these processes are and where they occur has not yet been definitively established, but low COD mass balances have been noted for many years in BNR research (McClintock *et al.*, 1988). Their existence would explain the consistently lower COD mass balances obtained in the BNRAS and ENBNRAS systems. Indeed, this consistent, but as yet unexplained, loss of COD is being intentionally included in some BNR system simulation models , e.g. BioWin (Barker *et al.*, 1996, 1997).

Figure 3.4 shows the COD mass balance for each sewage batch as a vertical bar, divided into the respective COD mass balance components. The full bar represents a 100% mass balance, with each component contributing a certain percentage to the total - the COD unaccounted for is added to the top of the bar to make up 100% COD. Figure 3.5 shows the overall averages of the COD mass balance components that contribute to the overall COD mass balance (the average being the average of all 30 sewage batch averages). On overall average, of the influent COD, 6.2% flowed out of the system with the effluent, 13.8% was passed to oxygen in the main aerobic reactor, 12.7% was utilized for denitrification in the pre- and main anoxic reactors, 19.7% was lost in the EN system, 26.7% left the system as waste sludge and 20.8% was unaccounted for. If there are in fact other biological processes in the ENBNRAS system to which the unaccounted COD loss can be ascribed, then just over 40% of the influent COD is unavailable to the main

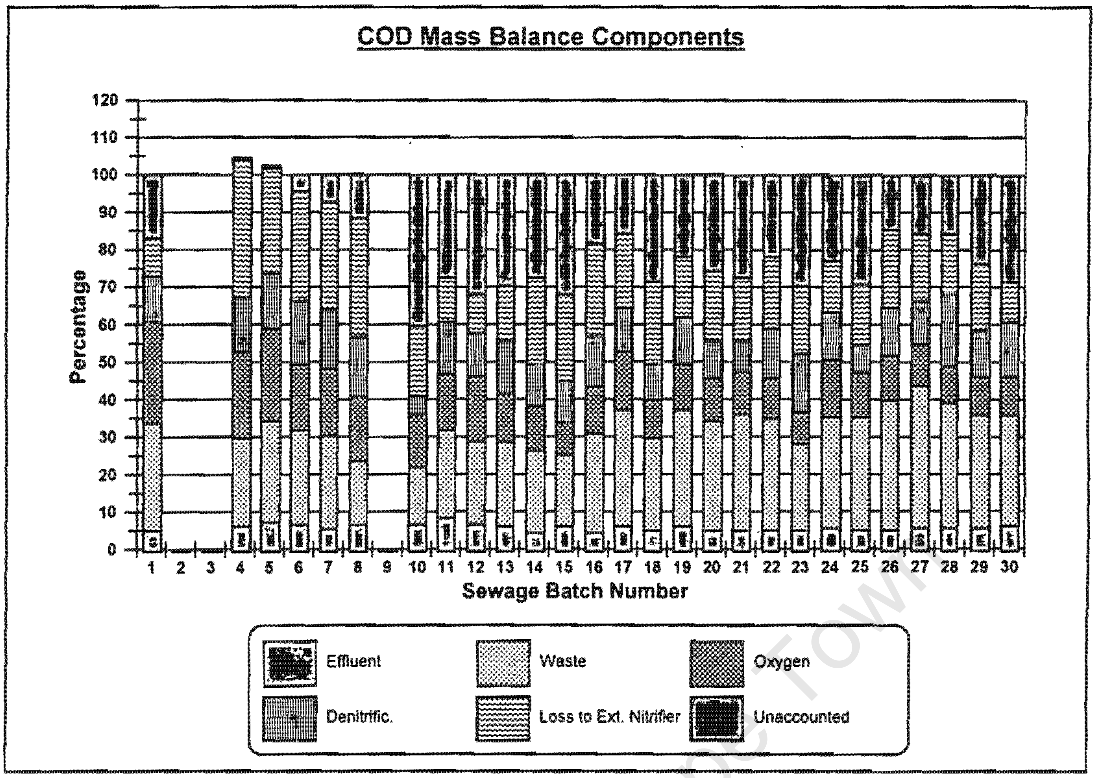

FIGURE 3.4 - COD mass balance components for sewage batches 1 to 30.

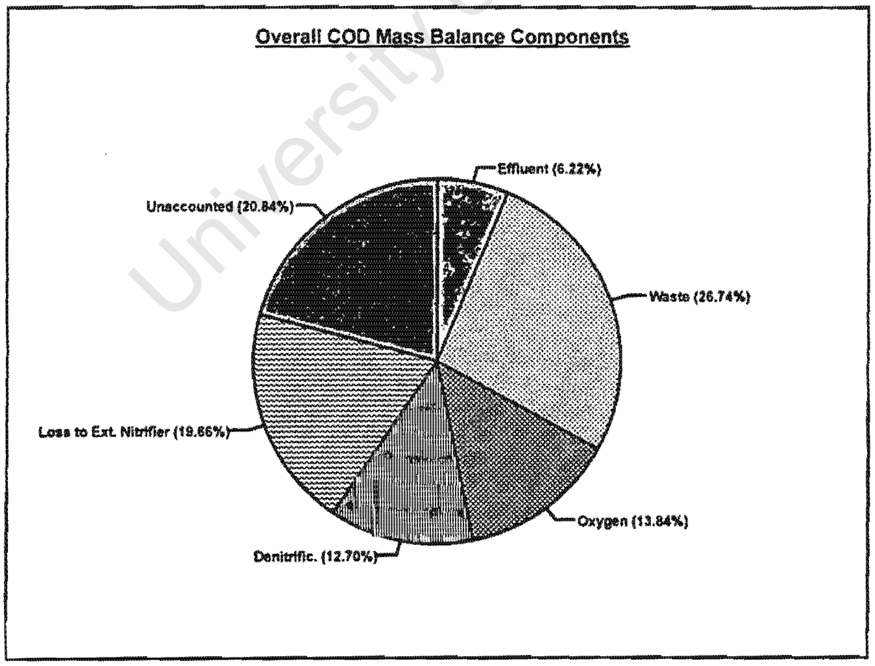

FIGURE 3.5 - Overall averages of COD mass balance components.

system. This is a very large amount, and if the 20.8% unaccounted for can be proven to go to a process that has not been identified and included in the measurements, the combined 40% can have a notable impact on the reactor volumes and OUR in full scale design of such plants.

Table 3.5b gives a comparison of the destination of the influent COD for the three ENBNRAS systems operated in the UCT laboratory.

TABLE 3.5b - Comparison of COD destinations in the three ENBNRAS systems.

Hu *et al.*	Moodley *et al.*	This investigation	COD Destination
8%	10%	6%	System effluent
30%	31%	27%	Waste
19%	13%	14%	Oxygen
16%	14%	13%	Denitrification
15%	12%	20%	'Lost' in EN system
10%	20%	20%	Unaccounted

The values from previous ENBNRAS systems compare well with the values calculated for this system. The main differences are in the COD lost in the EN system, where the systems of Hu *et al.* and Moodley *et al.* show significantly lower COD losses. The reason for this is that in both previous investigations fixed media stone columns were used for EN, while in this investigation a suspended medium activated sludge system was used, which seems more effective in removing the COD that flows into it. The COD in the waste sludge of both Hu *et al.* and Moodley *et al.* was about 3.3% and 4.3% higher, and this indicates that both their systems had a higher VSS mass than the system of this investigation, which is consistent with the "loss" of COD in the EN system. The COD utilised for denitrification is 3.3% higher in the system of Hu *et al.*, and 1.3% higher in that of Moodley *et al.* The reason that the two previous investigations show slightly higher values is that both had additional nitrate dosed to the main anoxic reactor and there was a period (up to sewage batch 15) where the main anoxic reactor of the system of this investigation denitrified poorly. The COD in the effluent of both Hu *et al.* and Moodley *et al.* was 1.9% and 3.9% higher than that of this system, and the higher effluent COD shows that the system of this investigation had better sludge flocculation and lower SS in the effluent.

3.3.1.2 COD removal performance

From Table 3.5, the overall COD removal (influent to effluent) is 94%, which is very good. The minimum removal is 91% and the maximum removal is 95%. Figure 3.6 indicates that the COD removal is not only very good, but it is also consistent. This COD removal is very close to the

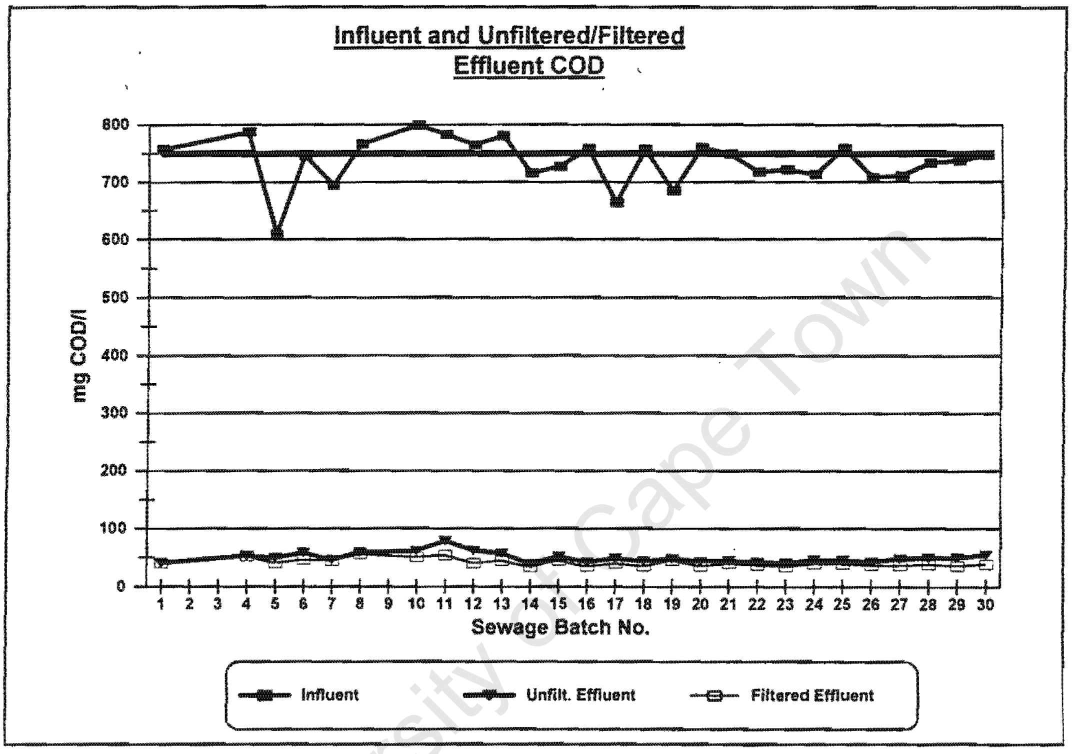

FIGURE 3.6 - Influent and unfiltered / filtered effluent COD concentrations for sewage batches 1 to 30.

COD removal observed by Hu *et al.* (1999) and Moodley *et al.* (1999) in their ENBNRAS systems, being 92% and 91% respectively. In this investigation, the system unfiltered effluent COD concentrations, as shown on Figure 3.6 and given in Table 3.4a, ranged between 39 mgCOD/l and 80 mgCOD/l with a mean of 50.6 mgCOD/l. The filtered effluent concentrations (filtered through Schleicher&Schuell 0.45μm membrane) ranged between 34 mgCOD/l and 57 mgCOD/l with a mean of 41.8 mgCOD/l. The filtered effluent value was accepted to correspond to the unbiodegradable soluble COD in the influent, giving an unbiodegradable soluble COD fraction ($f_{s,us}$) of 0.057.

The overall average OUR of the main aerobic reactor was 19.9 mgO/(l.h), this in an aerobic reactor comprising 20% of the system volume, which is very low when compared to an equivalent 'conventional' BNRAS system. Such a system with 20% aerobic mass fraction, 90% COD balance, 10 days sludge age, complete nitrification and 90% nitrate denitrification leading to 50% recovery in nitrification OUR has an OUR of around 75 mgO/(l.h). This is about 3.5 times higher and translates into a saving in oxygen of about 70%. As indicated by both Hu *et al.* (1999) and Moodley *et al.* (1999), not nitrifying in the BNRAS system and utilizing the nitrate generated externally results in a major decrease in OUR. Hu *et al.* (1999) observed an OUR of 29 mgO/(l.h) in 19% of the system volume, and Moodley *et al.* (1999) observed an OUR of 36 mgO/(l.h) in ~30% of the system volume. Both are higher than the OUR observed in this system, and the OUR observed by Moodley *et al.* (1999) is almost double the OUR observed here. The OUR of Moodley *et al.* (1999) is significantly higher because their EN system was not nitrifying efficiently throughout the investigation, at times causing a relatively large part of the nitrification to occur in the BNRAS system, hence resulting in a higher average OUR.

3.3.2 Nitrogenous Material Removal

3.3.2.1 Nitrogen mass balance

The nitrogen (N) mass balance is set up in a similar way to the COD mass balance. The N mass leaving the system in (i) the system effluent (TKN+NO_2+NO_3), (ii) denitrified in the pre- and main anoxic reactors (N_2 gas) and (iii) removed in the external nitrification (EN) system and (iv) in the waste sludge (TKN+NO_2+NO_3) is reconciled with the total influent nitrogen mass (for details, see Appendix B). As before, the closer the total N mass balance is to 100%, the more reliable the experimental data is deemed to be. In order to calculate the N exiting the system as N_2 gas, a separate nitrate and nitrite mass balance was set up to determine the net loss or gain in nitrate and nitrite in each reactor and settling tank. This was done by subtracting the NO_X mass leaving a reactor from the NO_X mass entering the same reactor. By virtue of this approach a negative value indicates a net gain in NO_X (i.e. nitrification), and a positive value indicates a net loss in NO_X (i.e. denitrification). Tables 3.6 a and b list the results for the nitrite and nitrate mass balances over each reactor and settler and Table 3.6c lists the results for the total N mass balance and all its components for sewage batches 1 to 30. Figure 3.7 shows the total N mass balances achieved for these sewage batches. Detailed results are listed in Appendix B.

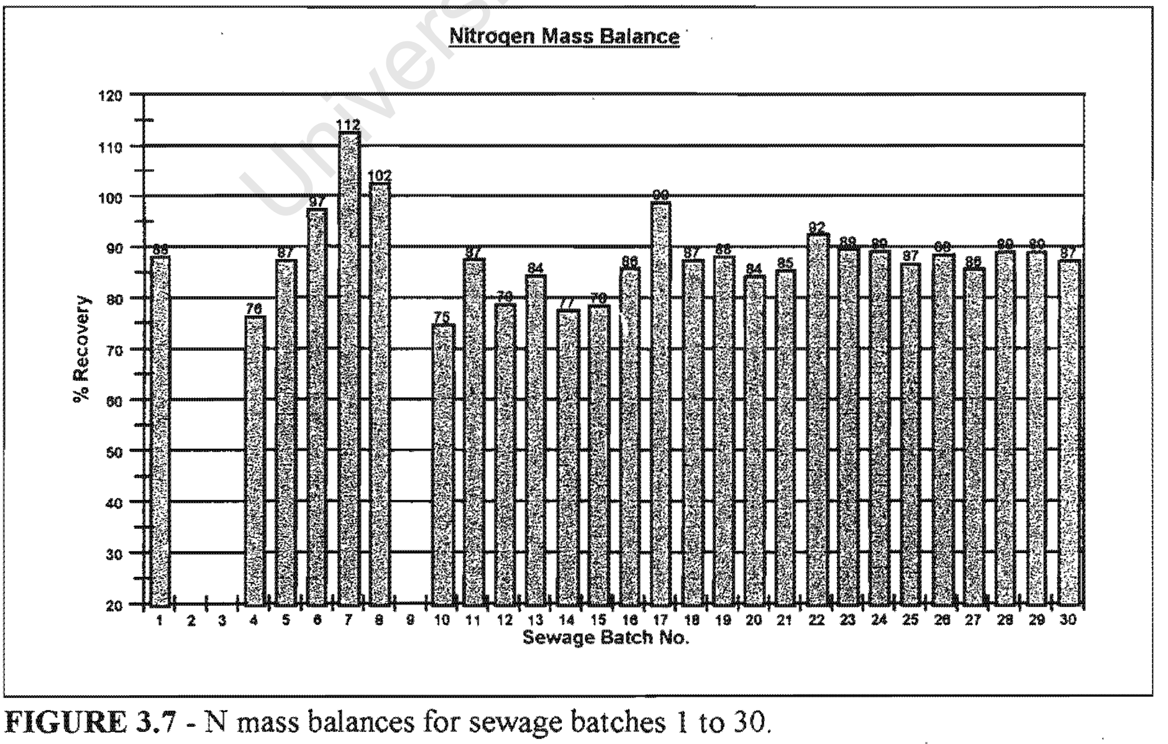

FIGURE 3.7 - N mass balances for sewage batches 1 to 30.

TABLE 3.6a - Nitrite mass balances across each reactor and settler for sewage batches 1 to 30.

Average of Batch	NITRITE						
	Δ PreANO mgN/d	Δ Anaerobic mgN/d	Δ Int. Set. A mgN/d	Δ Int. Set. B+Nit mgN/d	Δ Anoxic mgN/d	Δ Aerobic mgN/d	Δ Fin. SET mgN/d
1	1.2	-2.4	1.8	-86.4	78.0	-0.9	5.2
2	Bad Batch						
3	Bad Batch						
4	-18.8	31.0	0.4	-30.7	-74.9	69.1	8.8
5	-6.0	23.5	1.2	-92.6	7.2	41.4	3.4
6	30.6	-2.4	-0.3	-19.6	-43.2	-46.2	48.0
7	4.7	5.7	1.5	-15.9	-129.6	111.8	7.4
8	-23.1	61.7	5.1	-54.2	-94.3	34.0	23.1
9	Bad Batch						
10	27.4	3.4	-2.4	-255.6	184.8	-13.6	22.7
11	78.2	72.4	-6.0	-725.5	321.0	53.1	47.0
12	5.5	3.7	-1.0	-31.6	8.2	15.3	-10.3
13	-4.3	7.6	1.0	-4.3	-35.8	31.2	-0.8
Config. 1	*9.5*	*20.4*	*0.1*	*-131.6*	*22.1*	*29.5*	*15.4*
14	0.8	4.7	0.1	-5.1	-26.5	17.7	1.5
15	2.3	6.3	0.2	-4.0	-13.5	-0.8	-0.2
16	4.4	5.8	-1.1	-1.2	-59.6	37.0	3.2
17	-1.8	10.2	-0.2	-0.7	-100.9	70.3	12.7
18	2.7	-0.2	-0.8	-5.2	-27.0	20.4	6.2
19	2.8	12.1	0.0	-9.2	-40.9	10.1	8.6
20	1.3	-0.4	-1.1	-0.7	-4.3	0.2	3.0
Config. 2	*1.8*	*5.5*	*-0.4*	*-3.7*	*-39.0*	*22.1*	*5.0*
21	1.0	-0.3	-0.8	-3.5	3.2	-3.6	2.5
22	14.0	4.4	0.2	-3.1	-100.1	60.4	4.5
23	-0.7	10.3	-0.3	-7.0	-44.9	17.8	13.1
24	-1.2	11.0	0.4	0.1	-75.9	48.1	5.7
25	0.7	-0.1	-0.5	1.1	-1.6	-1.5	0.6
26	1.2	-0.7	-0.2	-4.7	1.6	1.7	-0.8
27	1.4	-1.1	0.3	-8.3	-7.0	13.8	-1.1
28	12.4	8.3	2.2	-2.7	-80.1	35.0	0.7
29	2.1	0.2	-0.5	0.4	-2.9	-3.0	0.6
30	2.4	0.4	-0.7	-0.9	-13.3	6.8	1.5
Config. 3	*3.3*	*3.2*	*0.0*	*-2.9*	*-32.1*	*17.5*	*2.7*
Overall	**5.2**	**10.2**	**-0.1**	**-50.8**	**-13.8**	**23.2**	**8.0**

TABLE 3.6b - Nitrate mass balances across each reactor and settler for sewage batches 1 to 30.

Average of Batch	NITRATE						
	Δ PreANO mgN/d	Δ Anaerobic mgN/d	Δ Int. Set. A mgN/d	Δ Int. Set. B+Nit mgN/d	Δ Anoxic mgN/d	Δ Aerobic mgN/d	Δ Fin. SET mgN/d
1	22.7	17.4	10.1	-424.5	482.3	-231.2	62.3
2	Bad Batch						
3	Bad Batch						
4	140.1	109.3	-0.2	-511.0	427.1	-359.2	-60.8
5	77.2	186.2	9.7	-585.2	226.8	-177.2	-18.5
6	137.8	10.0	3.2	-575.4	598.6	-260.2	-69.5
7	64.2	25.8	1.4	-611.8	586.5	-154.9	-9.5
8	124.9	80.1	9.8	-796.2	488.5	-88.5	-37.6
9	Bad Batch						
10	15.3	8.1	-0.2	-62.0	92.1	-74.7	-6.1
11	74.5	55.0	-3.8	-165.4	207.2	-289.5	-13.0
12	66.4	150.3	-1.1	-768.3	294.2	21.5	9.5
13	81.6	180.8	-0.2	-923.2	398.8	-49.5	35.7
Config. 1	*80.5*	*82.3*	*2.9*	*-542.3*	*380.2*	*-166.3*	*-10.8*
14	74.8	101.1	-1.6	-638.5	302.2	-39.3	16.1
15	43.3	198.6	-1.8	-749.7	261.7	-40.7	36.6
16	86.1	8.6	-3.1	-726.6	572.4	-54.8	16.9
17	69.6	13.4	-0.3	-476.6	371.6	-89.7	24.3
18	21.5	-1.4	-2.1	-432.9	461.6	-69.3	-1.7
19	91.1	57.9	-1.8	-669.8	387.6	-15.0	-3.5
20	8.7	-2.0	-1.8	-490.1	505.2	-27.8	-1.3
Config. 2	*56.4*	*53.7*	*-1.8*	*-597.7*	*408.9*	*-48.1*	*12.5*
21	7.9	-1.9	-2.2	-428.2	436.0	-28.0	7.4
22	61.9	0.7	-3.3	-625.7	555.9	-69.2	12.9
23	80.0	59.9	-1.6	-769.3	594.9	-95.0	-12.7
24	66.8	41.1	-1.6	-651.8	450.7	-49.9	31.0
25	15.9	-1.5	-2.0	-373.9	372.0	-26.5	-0.2
26	25.7	-1.2	-2.5	-598.5	601.2	-56.5	4.4
27	11.7	-1.5	-4.5	-556.4	559.5	-26.3	4.7
28	64.3	22.7	-6.6	-915.4	849.4	-95.5	-8.8
29	22.3	-1.5	-1.8	-586.9	588.8	-54.9	8.8
30	54.9	-2.0	-1.4	-707.2	661.6	-79.8	16.3
Config. 3	*41.1*	*11.5*	*-2.8*	*-621.3*	*567.0*	*-58.2*	*6.4*
Overall	**59.7**	**48.7**	**-0.4**	**-586.0**	**456.8**	**-95.6**	**1.6**

TABLE 3.6c - N mass balance with all components for sewage batches 1 to 30.

Average of Batch	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery	% N Removal
1	92.3	599.0	311.6	142.5	-93.1	1052.3	1207.7	88.0	88.2
2	Bad Batch								
3	Bad Batch								
4	109.3	687.7	226.1	421.0	-123.1	1321.0	1727.6	76.2	75.6
5	90.3	521.2	258.0	380.5	8.2	1258.3	1442.0	87.3	73.6
6	192.9	776.4	243.0	240.9	133.9	1587.2	1631.8	97.3	85.2
7	133.2	693.8	248.1	167.8	63.1	1305.9	1161.7	112.5	85.6
8	130.5	769.9	238.0	331.4	143.4	1613.2	1574.0	102.5	78.9
9	Bad Batch								
10	289.5	128.5	187.7	196.4	143.4	945.5	1267.2	74.6	84.5
11	635.8	388.5	265.9	351.1	-107.5	1533.7	1758.8	87.4	80.0
12	38.8	593.3	258.9	317.2	135.5	1343.8	1709.4	78.6	81.4
13	43.0	733.4	246.6	331.6	19.2	1373.7	1635.2	84.3	79.7
Config. 1	*175.6*	*589.2*	*248.4*	*288.0*	*32.3*	*1333.5*	*1511.6*	*88.9*	*81.3*
14	28.8	533.2	215.1	251.3	216.0	1244.4	1607.4	77.4	84.4
15	13.0	566.2	222.8	335.6	301.7	1439.3	1840.2	78.4	81.8
16	54.2	703.0	265.6	191.7	244.1	1458.5	1704.4	85.7	88.8
17	97.3	488.6	281.3	174.0	277.9	1319.1	1338.7	98.6	87.0
18	33.5	496.6	261.3	109.9	302.2	1203.5	1379.0	87.3	92.0
19	40.6	565.6	305.6	248.5	351.2	1511.6	1716.4	88.0	85.5
20	12.8	516.6	294.9	95.2	266.0	1185.5	1410.0	84.1	93.2
Config. 2	*40.0*	*552.8*	*263.8*	*200.9*	*279.9*	*1337.4*	*1570.9*	*85.6*	*87.5*
21	8.1	451.3	281.1	92.9	313.5	1146.9	1345.2	85.3	93.1
22	86.5	634.6	296.8	162.5	313.4	1493.8	1618.1	92.3	90.0
23	46.9	754.0	271.1	233.4	243.2	1548.6	1732.4	89.4	86.5
24	72.1	611.5	311.1	210.5	377.9	1583.1	1780.8	88.9	88.2
25	2.7	392.2	307.6	107.7	320.8	1131.0	1306.7	86.6	91.8
26	9.5	633.9	347.8	113.9	324.5	1429.6	1627.1	88.4	93.0
27	19.3	576.8	324.3	94.1	219.1	1233.7	1451.1	85.6	93.5
28	65.1	951.8	302.9	185.0	97.1	1601.9	1802.9	88.9	89.7
29	6.8	622.2	304.9	114.0	213.2	1261.0	1420.8	88.8	92.0
30	13.9	732.9	290.2	126.7	188.2	1351.9	1554.4	87.1	91.8
Config. 3	*33.1*	*636.1*	*303.8*	*144.1*	*261.1*	*1378.2*	*1564.0*	*88.1*	*91.0*
Overall	**87.7**	**597.1**	**272.9**	**212.1**	**181.2**	**1351.0**	**1546.3**	**87.8**	**86.5**

As can be seen from Table 3.6c and Figure 3.7, the overall N mass balance achieved was 87.8%. This is significantly better than the COD balance, which was 80%. This indicates that the system design parameters such as flows, volumes and sludge age which are used for the N balance also, are accurately established and not the major cause for the low COD balances. It also confirms that the low COD balances are most likely a consequence of biological processes not included (captured) with the tests performed on the system. The lowest N mass balance was 74.6% for sewage batch 10, and again this is the sewage batch immediately following the toxic sewage batch (batch 9) and can be attributed to the fact that the system was still adversely affected by the toxic sewage batch. The best N balance was 98.6% for sewage batch 17. As was noted above for the

COD mass balances, the N mass balances also become more stable after sewage batch 10 and level off at around 90% from sewage batch 15, which is the sewage batch where the system has fully recovered from the toxic sewage batch 9.

The overall N mass balance of 87.8% compares well with those obtained in other investigations on BNRAS and ENBNRAS systems, as shown in Table 3.6d. This shows that the balance obtained for this system is within the range of N mass balances established in BNRAS and ENBNRAS system investigations in the past.

TABLE 3.6d - N mass balances obtained for BNRAS and ENBNRAS systems in the past.

Researcher	System	N Mass Balance
Kaschula *et al.* (1993)	BNRAS system	89%
Pilson *et al.* (1995)	BNRAS system	97%
Sneyders *et al.* (1997)	BNRAS system	92%
Mellin *et al.* (1998)	BNRAS system	82%
Hu *et al.* (1999)	ENBNRAS system	86%
Moodley et al. (1999)	ENBNRAS system	91%
This investigation	ENBNRAS system	88%

Figure 3.8 below gives a graphical representation of the N mass balances and the individual components which contribute to it; each bar represents the total N mass balance for a sewage batch with the individual mass balance components stacked above one another, including the N not accounted for in the N mass balance to make up the total 100% influent N. Figure 3.9 shows the components of the N mass balance averaged for sewage batches 1 to 30.

From Figure 3.8 it can be seen that, together, the nitrate and nitrite denitrification make up the biggest component of the N mass balance, amounting to 44.3%. This is largely due to the large anoxic mass fraction of the system (0.42 for Configuration 1 and 0.55 for Configurations 2 and 3). The contribution of nitrite denitrification is in general very small, which is to be expected; however in sewage batches 10 and 11 this contribution is abnormally large, because of the toxic sewage batch 9. As mentioned before, the sewage batch had a major inhibition effect on the Nitrite oxidizers (which convert nitrite to nitrate) which reduced this process to an abnormally

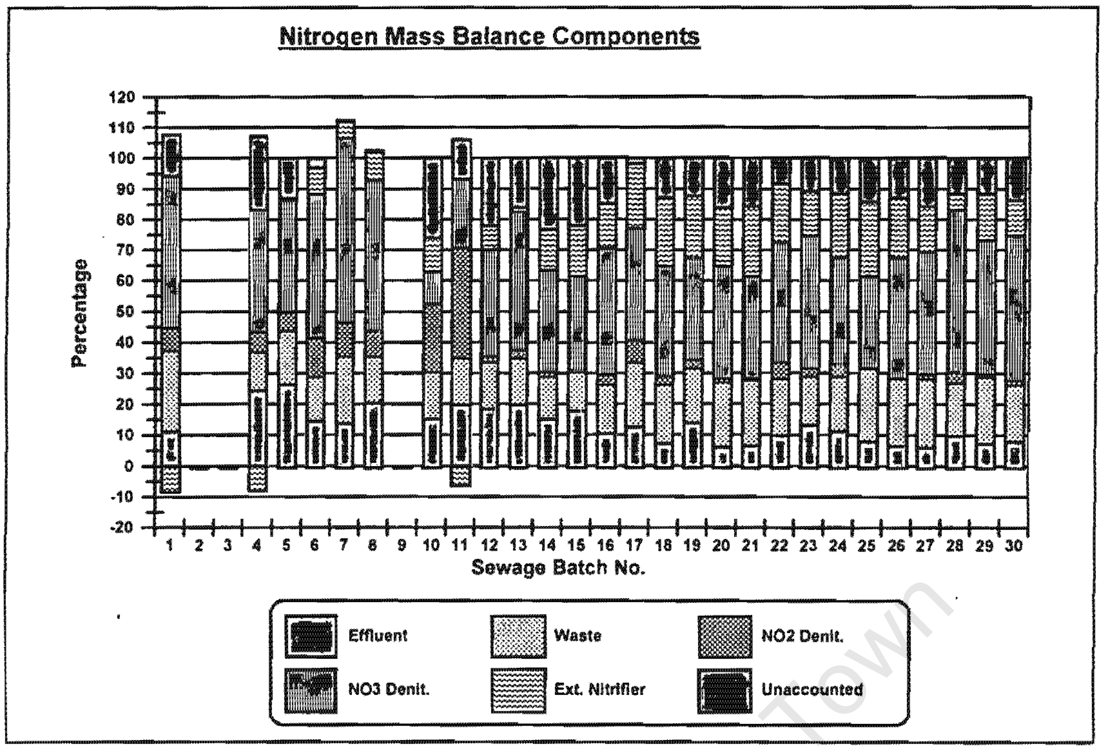

FIGURE 3.8 - N mass balance components for sewage batches 1 to 30.

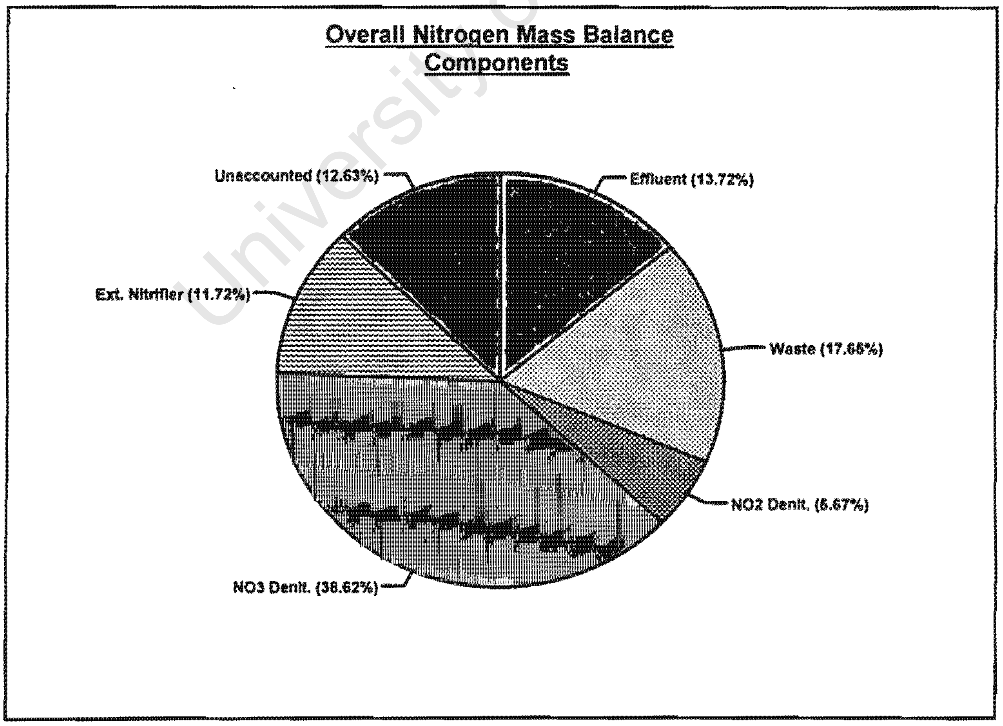

FIGURE 3.9 - Overall averages of N mass balance components.

low level, leading to a high production of nitrite. The N exiting the system in the waste sludge is fairly constant, which is expected because an equal volume of mixed liquor was wasted daily. The N exiting the system in the effluent was not as constant as the COD exiting the system with the waste sludge. This is because the effluent N comprises TKN, nitrate and nitrite. The nitrate and nitrite concentrations are dependent on the nitrification and denitrification performance of the system, and if the nitrate generated is larger than the denitrification capacity, the excess NO_X will appear in the effluent. The mass of N lost in the EN system was much larger than expected from the COD loss, especially after sewage batch 13, but this will be discussed below in Section 3.3.2.2 - Nitrification.

From Figure 3.9 the overall average N mass balance components are as follows: About 14% of the influent N flowed out of the system with the effluent. Of this 14%, 6% was TKN and 8% was NO_X. Roughly 44% of influent N was denitrified in the pre-anoxic, anaerobic and main anoxic reactors and escaped to the atmosphere, of which 4.8% was in the pre-anoxic reactor, 4.3% in the anaerobic reactor and 35.2% in the main anoxic reactor. About11.7% was removed in the EN system, and a further 17.7% was drawn off as waste sludge, leaving about 12.6% unaccounted for.

The overall N mass balance components for the ENBNRAS system investigations of Hu *et al.* (1999) and Moodley *et al.* (1999) are given in Table 3.6e.

TABLE 3.6e - Overall N mass balance components for the ENBNRAS systems investigated by Moodley *et al.* and Hu *et al.* and for this investigation.

Hu *et al.*	Moodley *et al.*	This investigation	
12%	29%	14%	In the system effluent
9%	7%	12%	'Lost' in EN system
52%	38%	44%	Denitrified
13%	17%	18%	In waste sludge
14%	9%	12%	Unaccounted for

The results obtained for the system of this investigation compare well with those obtained by Hu *et al.* (1999), the largest difference occurring in the denitrification. In the system of Hu *et al.* 7.7% more influent N was denitrified. The reason for this is that additional nitrate was dosed to the main anoxic reactor of that system, while none was dosed to the system in this investigation. The system of Moodley *et al.* had about 16% more nitrogen in the effluent, which is due to the poor performance of the EN system (stone column) used. The EN system of Moodley *et al.* also removed about 5% less N, while the entire system denitrified about 6% less N, even though, as in the investigation of Hu *et al.*, additional nitrate was dosed to the system to compensate for the poor nitrification in the EN system. In the broad perspective, and taking account of the difficulties experienced, there are no unacceptable deviations between the three ENBNRAS systems in terms of the nitrogenous compounds, and their results are acceptably consistent.

3.3.2.2 Nitrification

In this system, nitrification was achieved externally in a completely mixed activated sludge nitrification system. The flow from the anaerobic reactor was settled in internal settler A (see Figure 3.1). The supernatant passed to the EN system and the sludge bypassed directly to the main anoxic reactor. With an influent flow of 20 litres a day and a s-recycle of 1:1, the flow from the anaerobic reactor was 40 l/d. An average of 4.2 l/d was bypassed to the main anoxic reactor with the sludge bypass, leaving 35.8 l/d to flow through the EN system. From Tables 3.4a and 3.4c it can be seen that the overall average free and saline ammonia (FSA) concentration flowing into the EN system was 28.3 mgN/l and the overall average of FSA after the EN system (and internal settler B) was 4.9 mgN/l. However, the average of 4.9 mgN/l is a consequence of the high FSA concentration in the EN system outflow during sewage batches 4, 10 and 11, which resulted from nitrification inhibition as a result of the toxic sewage batches 2 and 9. The average outflow FSA from sewage batch 12 to 30 is 3.2 mgN/l, illustrating that about 89% of the FSA flowing into the EN system is converted to nitrate, with a small part of the FSA being incorporated into the sludge. Hence, only the small residual FSA fraction from the EN system and the FSA in the sludge bypass was available for nitrification in the main aerobic reactor.

Figure 3.10 shows the mass of NO_X produced per day by nitrification in the entire system as a bar for each sewage batch, each bar showing the mass nitrified in the EN system and how much was nitrified in the main aerobic reactor of the main system. Figure 3.11 shows the overall average (as a percentage) of nitrification occurring in the EN system and in the main aerobic reactor.

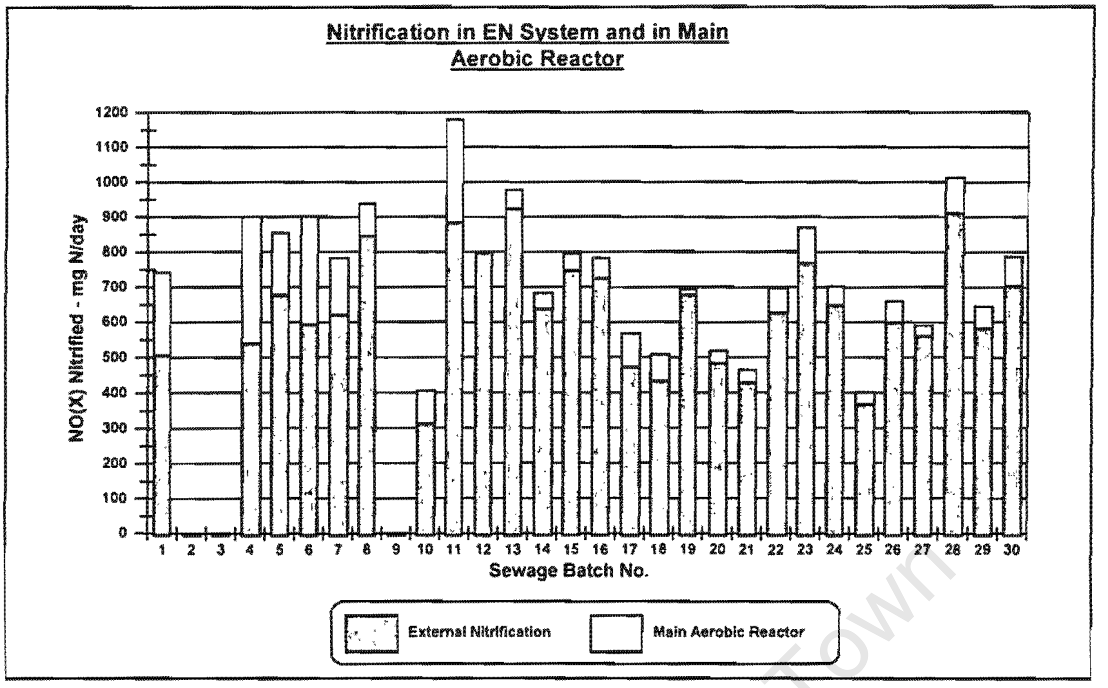

FIGURE 3.10 - NO_X produced by nitrification in EN system and main aerobic reactor for sewage batches 1 to 30.

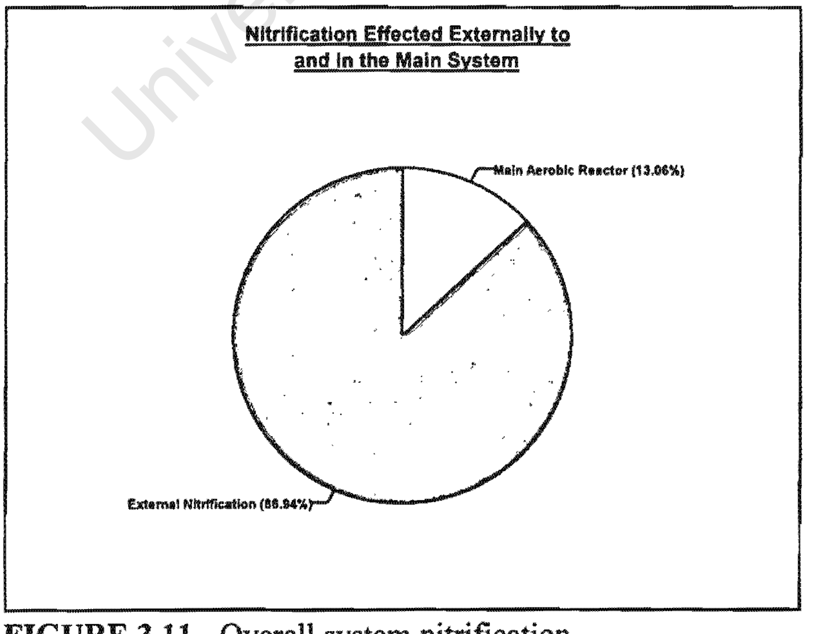

FIGURE 3.11 - Overall system nitrification.

As can be seen from Figure 3.10, the bulk of the nitrification (86%) occurred in the EN system. In the beginning of the investigation (sewage batches 1 to 8) the EN system was not yet operating at full capacity, and the main aerobic reactor compensated for the lower capacity. The reason for this lower nitrification efficiency was insufficient aeration in the EN reactor. To overcome this, a DO controller / OUR meter was installed on the reactor with the high and low DO set points set between 2 and 4 mgO/l. This ensured that the DO remained high in the reactor. After this modification and the toxic sewage batch 9, nitrification was virtually complete in the EN reactor throughout the investigation (except for sewage batch 11) and the effluent FSA (from internal settler B) levelled off at around 3 mgN/l, with the main aerobic reactor nitrifying only the residual FSA of the EN system and the FSA from the sludge bypass, as mentioned above.

The consistency of the FSA concentration prompted an enquiry into whether this was in fact 3 mgN/l FSA or a titration end point detection problem. Accordingly, FSA standards of 0 to 5 mgN/l at 0.5 mgN/l intervals were made up and tested. These tests confirmed that (i) end point detection was good and within 1 mgN/l and (ii) the EN system did not nitrify completely (0 mgFSA-N/l) but virtually completely (3 mgFSA-N/l).

Figure 3.11 shows that on average over the 30 sewage batches about 86% of the nitrification occurred externally, confirming that this system was run as a true ENBNRAS system with only very little nitrification occurring in the main aerobic reactor. Hu *et al* (1999) reported a value of 88% and Moodley *et al* (1999) a value of 76%. This indicates that it is difficult to remove nitrification from the main system in its entirety, and one can expect about 13% of the overall nitrification to occur in the main system. This means that practically only about 85% of the nitrification can be affected externally, depending on the magnitude of the bypass flow.

It was noted during the investigation that denitrification was occurring in the EN system. Nitrogen gas bubbles formed in the piping of the EN reactor, and gas bubbles were also noted in internal settler B, leading to an occasional rising sludge problem. This denitrification in part explains the seemingly high N removal in the EN system noted in the N mass balance (11.7%, Figure 3.9). This N removal is more than reasonably can be expected to be incorporated into the sludge mass for growth in the EN system, especially in view of the very long sludge age at which this system was operated. Denitrification occurring in this system therefore is the likely reason for the high N removal noted. Curiously though, the N 'loss' was greatest during the time when the aeration in the reactor was controlled with the DO controller / OUR meter, and lowest when not controlled and possibly under aerated (see Table 3.6c). In the single reactor system it is not possible to determine the extent of denitrification, because N incorporated into the sludge and denitrification are lumped together as N loss in nitrifier. Without denitrification the N loss in the EN system is likely to be lower than 11.7%, so its nitrate generation was probably higher than measured with denitrification.

3.3.2.3 Denitrification

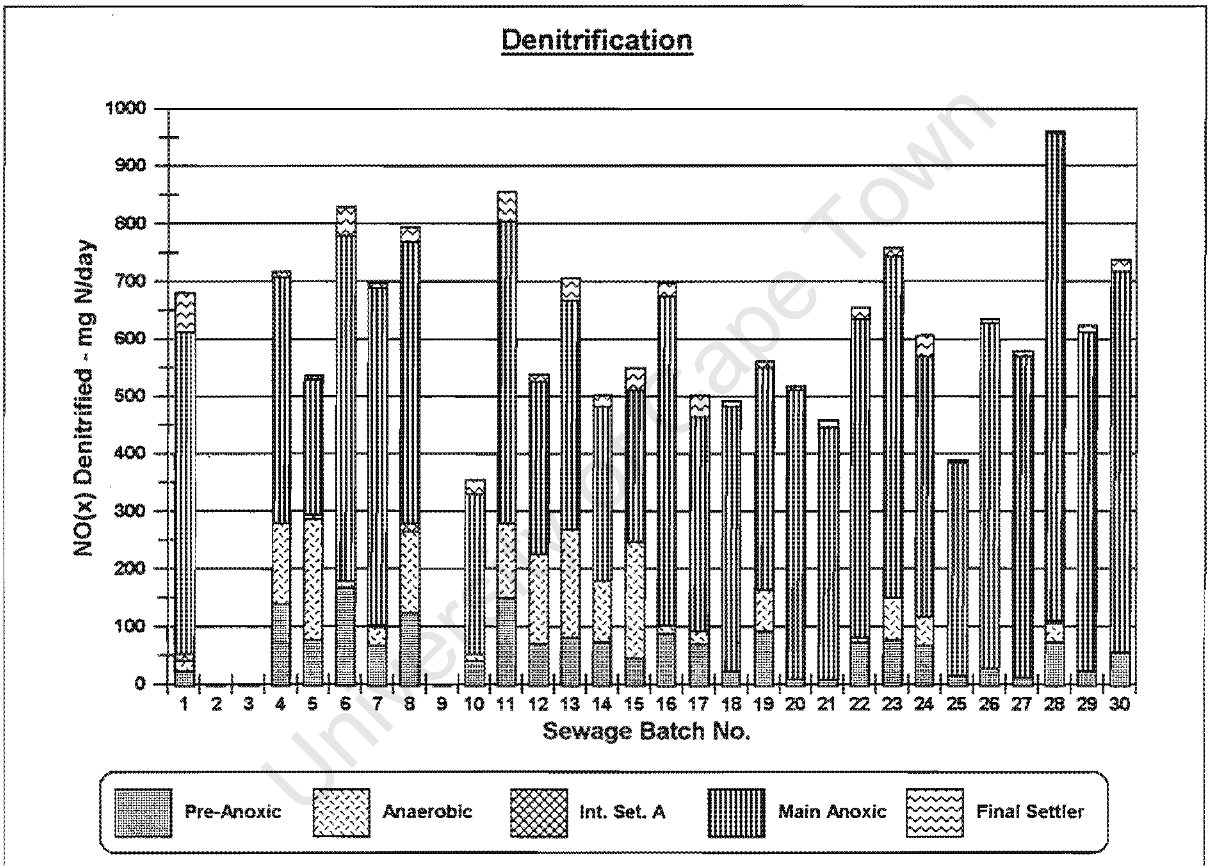

FIGURE 3.12 - NO_X denitrification for sewage batches 1 to 30.

Figure 3.12 shows the total amount of NO_X denitrified (as mgN/d) in the system during each sewage batch as the total height of the bar, as well as the mass of nitrate denitrified in each respective reactor. Figure 3.13 shows the overall average percentage denitrification of the system total in each reactor. From Figure 3.12 it can be seen that little denitrification occurred in both the final settler and internal settler A. By far the largest mass of NO_X was denitrified in the main anoxic reactor. When denitrification was not complete in the main anoxic reactor, some nitrate was recycled in the s-recycle and denitrified in the pre-anoxic reactor. If the nitrate load on the pre-anoxic reactor exceeded its denitrification potential (~5mgN/l influent), the outflow nitrate

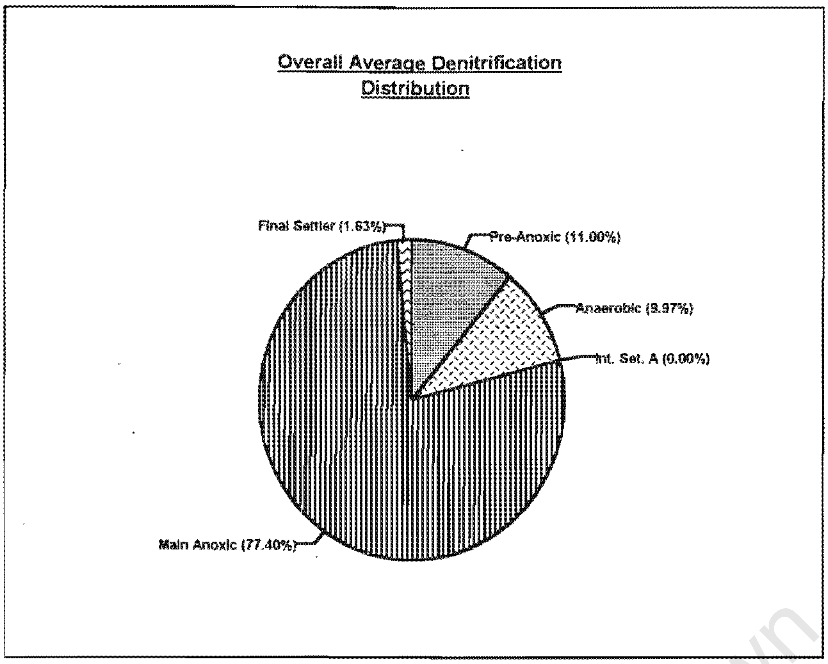

FIGURE 3.13 - Overall average denitrification distribution.

was then denitrified in the anaerobic reactor. Figure 3.12 and Table 3.6b show that in 19 out of the 30 sewage batches nitrate was flowing into the anaerobic reactor. Sewage batches 4, 5, 8, 11, 12, 13, 14 and 15 show a large mass of nitrate (Table 3.6b) denitrified in the anaerobic reactor, and this will have negatively impacted the P release and P removal performance. This shows that during these sewage batches the main anoxic reactor did not denitrify very well. This aspect is discussed in greater detail below. Towards the end of the investigation (sewage batches 16 to 30) the denitrification performance of the main anoxic reactor improved, and the nitrate flowing into the anaerobic reactor was due to higher influent TKN/COD ratios, rather than to poor denitrification performance in the main anoxic reactor.

Figure 3.13 shows that, on average over the 30 sewage batches, about 77% of the denitrification occurred in the main anoxic reactor, 11% in the pre-anoxic reactor and about 10% in the anaerobic reactor. The remaining ~1.6% occurred in internal settler A, and in the final settler. As mentioned earlier, the fact that ~10% of the overall denitrification occurred in the anaerobic reactor at relatively low influent TKN/COD ratios and without additional nitrate dosing, indicated a poor denitrification performance of the main anoxic reactor, principally during sewage batches 11 to 15 following the toxic sewage batch 9.

The denitrification potential of the pre- and main anoxic reactors can only be calculated if the measured NO_X concentrations in these reactors exceeded 1 mgN/l to ensure that the nitrate load exceeds the denitrification potential. If the NO_X concentrations are below 1 mgN/l, the reactors are likely to be underloaded and hence the denitrification potential cannot be established. From Table 3.4c it can be seen that for the pre-anoxic reactor, the denitrification potential can be calculated for all sewage batches except for sewage batches 10, 17, 18, 20, 21, 22, 25, 26, 27, 29 and 30. For the main anoxic reactor, the denitrification potential can be calculated for all sewage batches except for sewage batches 18, 20, 21, 25, 26, 27 and 29. Table 3.7 below lists the results obtained for the denitrification potential of these two anoxic reactors and Figure 3.14 shows these graphically.

TABLE 3.7 - Denitrification potential of the pre- and main anoxic reactors for sewage batches where the outflow NO_X concentration exceeds 1 mgN/l.

	Main Anoxic		Pre Anoxic		Total Anoxic
Batch	NO(x) Denitrified mgN/d	Denit. Potential mgN/l infl.	NO(x) Denitrified mgN/d	Denit. Potential mgN/l infl.	Mass Fraction of System
1	560	28.0	24	1.2	0.42
2	-	-			0.42
3	-	-			0.42
4	427	21.4	140	7.0	0.42
5	234	11.7	77	3.9	0.42
6	599	29.9	168	8.4	0.42
7	587	29.3	69	3.4	0.42
8	489	24.4	125	6.2	0.42
9	-	-			0.42
10	277	13.8	43		0.42
11	528	26.4	153	7.6	0.42
12	302	15.1	72	3.6	0.42
13	399	19.9	82	4.1	0.42
Config.1		22.0		5.1	0.42
14	302	15.1	76	3.8	0.55
15	262	13.1	46	2.3	0.55
16	572	28.6	91	4.5	0.55
17	372	18.6	70		0.55
18	462		24		0.55
19	388	19.4	94	4.7	0.55
20	505		10		0.55
Config.2		19.0		3.8	0.55
21	439		9		0.55
22	556	27.8	76		0.55
23	595	29.7	80	4.0	0.55
24	451	22.5	67	3.3	0.55
25	372		17		0.55
26	603		27		0.55
27	559		13		0.55
28	849	42.5	77	3.8	0.55
29	589		24		0.55
30	662	33.1	57		0.55
Config.3		31.1		3.7	0.55
Overall		23.5		4.5	-

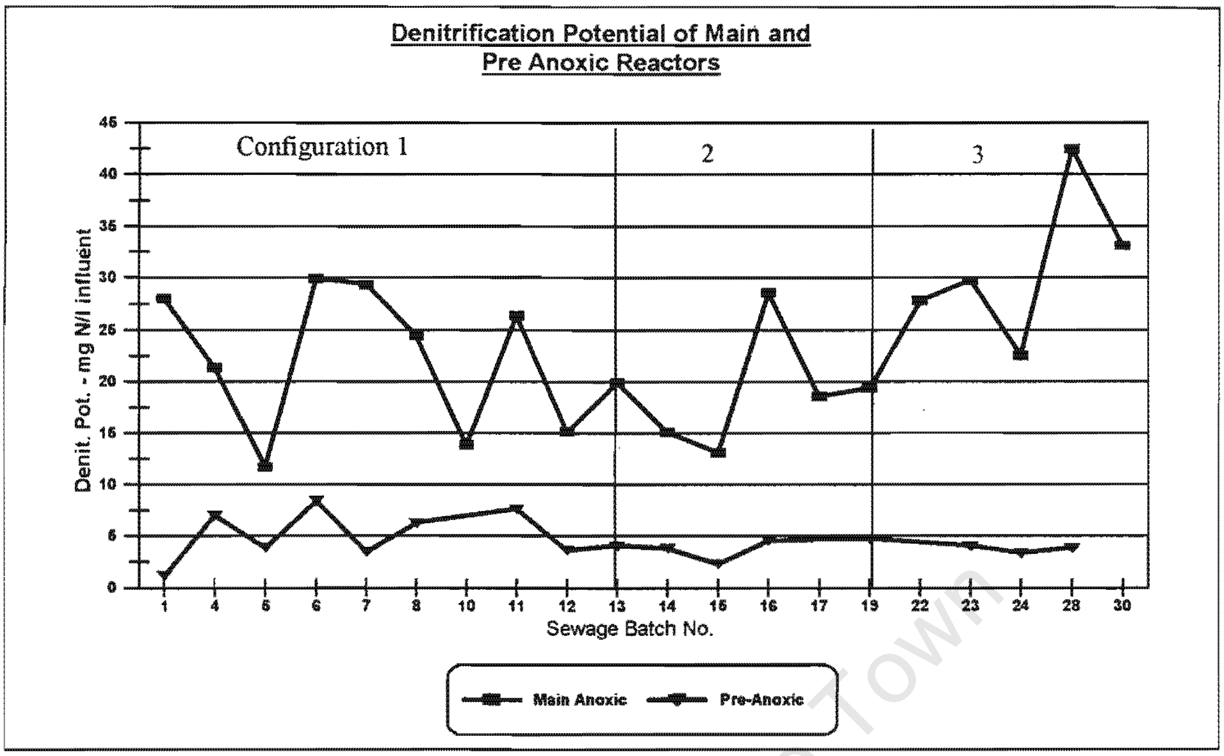

FIGURE 3.14 - Denitrification potential of pre- and main anoxic reactors.

Table 3.7 and Figure 3.14 show that the overall average denitrification potential for the main anoxic reactor was 22.0 mgN/l influent at an anoxic mass fraction of 0.33 (Configuration 1) and 19.0 and 31.1 mgN/l influent at an anoxic mass fraction of 0.45 (Configurations 2 and 3 respectively). The overall average denitrification potential for the pre-anoxic reactor was 4.5 mgN/l influent at an anoxic mass fraction of 0.1 for Configurations 1 to 3. Moodley *et al.* (1999) found overall average denitrification potentials of 41, 28, and 27 mgN/l influent at main anoxic reactor mass fractions of 0.5, 0.45 and 0.3 respectively for their system.

It can further be seen from Table 3.7 that sewage batches 1 to 8 showed reasonable denitrification potential for the main anoxic reactor, but after the toxic sewage batch, batch 9, it dropped sharply. With the exception of sewage batches 11 and 16, the denitrification potential did not recover fully until about sewage batch 21. The increase in the main anoxic reactor volume from 6.5 to 9 litres (the change from Configuration 1 to Configuration 2 at the end of sewage batch 13) had no effect and therefore the average denitrification potential for Configuration 2 remained low at 19 mgN/l influent. After sewage batch 21 the denitrification potential started to increase (this coincided with the change to Configuration 3, i.e. the elimination of the a-recycle at the end of sewage batch 20) and it remained at reasonably higher values until sewage batch 30, with a maximum of 42.5 mgN/l influent for sewage batch 28. The denitrification potential of the pre-anoxic reactor remained approximately constant throughout. From the above, it appears that the a-recycle is detrimental to the denitrification potential (rate). The a-recycle was first introduced in the investigation of Moodley *et al.* (1999) due to low nitrification in the EN system, resulting in nitrification and high nitrate concentrations in the main aerobic reactor. To reduce this high nitrate concentration so as not to recycle high nitrate concentrations to the pre-anoxic and anaerobic reactors, the a-recycle was introduced in the system. An a-recycle was retained in the system of this investigation in the event of poor nitrification performance of the EN system, thinking that it would not adversely affect the performance of the system, but it does appear to be detrimental to the system performance. Under normal circumstances (good nitrification in the EN system) the a-recycle is not required. The interrelationship between the denitrification performance and biological P removal is discussed in Section 3.3.3 below.

3.3.2.4 Nitrogen removal performance

From Table 3.6c it can be seen that the overall N removal of the system was 86.5%, which is very good, considering the long period of poor denitrification performance described above. Had it not been for the period of poor denitrification, the overall N removal would have been higher. In the investigation of Moodley *et al.* (1999) an overall N removal of 75% was found, but in that investigation the nitrification efficiency of the EN system (stone column) was low resulting in high effluent TKN concentrations (~10 to 15 mgN/l) and also additional nitrate was dosed, resulting in an overall higher TKN/COD ratio to the main anoxic reactor and in higher nitrification in the main aerobic reactor. These factors resulted in higher effluent NO_X and TKN concentrations, and hence seemingly poorer N removal performance.

Figure 3.15 below shows the total N (TN) in the effluent (TKN plus NO_X) for each sewage batch against the total influent TKN as the whole bar height. From Figure 3.15 it can be seen that the effluent TN contains a fairly constant mass of TKN for all the sewage batches because nitrification was virtually complete in the EN system. The variability in the effluent TN is due to the NO_X component of the effluent TN. On overall average, the effluent contained 92.9 mgN/d TKN (43% of TN or 4.7 mgN/l) and 119.2 mgN/d NO_X (57% of TN or 6.2 mgN/l). Since the influent nitrogen consists entirely of TKN, the average TKN is effectively reduced in total by about 94%. The lower N removal of 86% is due to the NO_X in the effluent. The variability in effluent NO_X is due to the fact that it is dependant on the mass of NO_X produced in the system by nitrification, and the mass of NO_X removed by denitrification, which are dependent on the TKN/COD ratio of

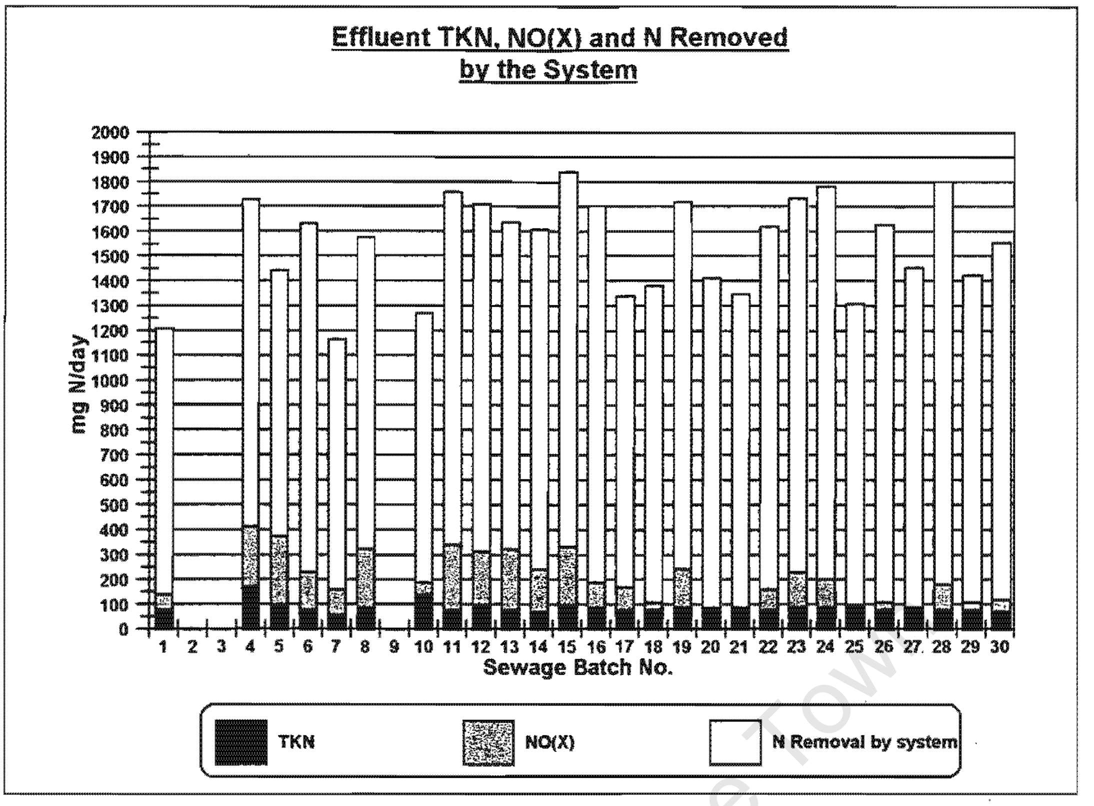

FIGURE 3.15 - Nitrogen in the effluent as part of influent nitrogen.

the influent sewage. For this system, the TN removal could have been closer to the 94% TKN removal, if the denitrification performance had not been affected by the toxic sewage fed in sewage batch 9. For Configuration 3, when denitrification was good, the average effluent TN achieved was 7.2 mgN/l of which 2.5 mgN/l was NO_X and 4.7 mgN/l was TKN. Thus, it would appear that the EN system has the potential to produce effluents with less than 10 mgN/l TN.

3.3.3 Biological Excess Phosphorus Removal (BEPR)

3.3.3.1 Phosphorus removal performance

The phosphorus (P) mass balances over the reactors and settling tanks do not provide a check on the experimental results as the COD and N mass balances do; they only provide a check on the P release and P uptake calculations in that the sum of the P uptakes and P releases in each of the reactors and settling tanks should be equal to the system P removal, i.e. the difference between the influent and effluent P concentrations (see Appendix B). The P mass balances over each reactor and settling tank in the system are important, because they show the mass of P release/uptake that takes place in each of the reactors and settling tanks and provide an overall summary of the BEPR processes and performance through the system. Table 3.8 below lists the results of the P mass balances based on the sewage batch average measured P concentrations on each of the reactors and settling tanks of the system. Also given in Table 3.8 are the average P releases or uptakes in each reactor and settling tank for Configurations 1, 2 and 3, and the investigation overall. Because the P mass balance is set up by subtracting the outflow P mass from the inflowing P mass, a negative result indicates P release and a positive result a P uptake. The shaded fields in Table 3.8 indicate those results that were affected by the error that occurred in the analytical procedure which was described in Section 3.2.2. Figure 3.16 shows graphically the contribution of each reactor/settling tank to the total P release and uptake as a stacked bar for sewage batches 10 to 30. In Table 3.8 and Figure 3.16 the calculated P release or uptake mass was divided by the influent flow to give the P release or uptake in mgP/l influent.

From Table 3.8 it can be seen that the overall average P removal for the system was 9.8 mgP/l influent for an average influent COD of 736 mgCOD/l (see Table 3.4a) and an average influent readily biodegradable COD (RBCOD) concentration of 142 mgCOD/l. The P removal performance did not vary much in the three system configurations; it was slightly lower (9.1 mgP/l influent) in Configuration 2 compared with Configuration 1 (9.7 mgP/l influent), but this was probably the result of a combination of the poor denitrification performance due to the toxic sewage fed in sewage batch 9 and the toxic effect itself on the polyphosphate accumulating organisms (PAOs) over the same period because the change from Configuration 1 to Configuration 2 (enlarged anoxic mass fraction and decreased aerobic mass fraction) should have

TABLE 3.8 - Average P release (-ve) or P uptake (+ve) for each reactor/settling tank and total P removal for sewage batches 1 to 30.

Batch	Δ Pre-ANO mgP/l infl.	Δ Anaerobic mgP/l infl.	Δ Int.SET A mgP/l infl.	Δ Int. SET B+Nit. mgP/l infl.	Δ Anoxic mgP/l infl.	Δ Aerobic mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Total P Removal	% Recovery
1	-2.4			-5.8	39.7			15.3	15.3	100
2	Bad Batch									
3	Bad Batch									
4	1.5			0.6	32.6			7.9	7.9	100
5	1.3			-5.5	36.7			3.7	3.7	100
6	0.1			-8.6	24.1			13.6	13.6	100
7	1.0			-8.8	42.2			11.2	11.2	100
8	2.1			-6.1	21.0			6.7	6.7	100
9	Bad Batch									
10	0.1	-8.6	-3.8	5.2	4.2	12.0	0.4	9.6	9.6	100
11	2.0	-7.8	-8.7	-4.9	9.5	15.8	0.9	7.0	7.0	100
12	2.0	-6.6	-6.6	-5.0	10.2	19.5	0.4	13.9	13.9	100
13	0.7	3.2	-4.4	-4.4	4.8	8.3	0.3	8.5	8.5	100
Config. 1	*0.8*	*-4.9*	*-5.9*	*-4.3*	*22.5*	*13.9*	*0.5*	*9.7*	*9.7*	*100*
14	2.6	-7.6	-6.6	-3.6	12.5	10.5	0.1	7.8	7.8	100
15	0.9	-2.4	-6.7	-3.9	12.2	7.9	3.2	11.3	11.3	100
16	2.0	-17.5	-3.9	-2.1	17.5	14.6	-0.2	10.3	10.3	100
17	2.6	-12.5	-3.5	-5.6	14.4	11.1	1.1	7.5	7.5	100
18	-0.1	-16.8	-2.9	-2.7	18.8	13.6	0.2	10.1	10.1	100
19	1.9	-7.6	-5.9	-5.7	13.2	8.9	1.6	6.2	6.2	100
20	-1.3	-12.7	-4.0	-4.2	17.3	13.7	1.6	10.4	10.4	100
Config. 2	*1.2*	*-11.0*	*-4.8*	*-4.0*	*15.1*	*11.5*	*1.1*	*9.1*	*9.1*	*100*
21	-1.2	-12.2	-2.8	-5.3	13.3	17.1	0.9	9.9	9.9	100
22	1.0	-13.4	-4.4	-5.1	18.3	10.3	2.6	9.3	9.3	100
23	1.5	-10.1	-2.7	-3.6	14.1	6.8	0.4	6.4	6.4	100
24	0.9	-10.9	-4.8	-6.1	18.3	9.9	2.4	9.8	9.8	100
25	-2.0	-17.8	-4.3	-4.6	21.4	18.2	0.0	10.8	10.8	100
26	-1.9	-26.2	-4.6	-4.0	33.0	16.7	1.2	14.3	14.3	100
27	-0.4	-16.5	-6.1	-5.9	26.3	11.6	0.1	9.0	9.0	100
28	1.4	-19.9	-4.1	-5.5	28.0	9.2	1.3	10.3	10.3	100
29	-0.1	-20.5	-3.6	-5.2	26.8	13.4	0.6	11.4	11.4	100
30	1.0	-19.7	-3.4	-6.1	24.0	15.7	2.1	13.6	13.6	100
Config. 3	*0.0*	*-16.7*	*-4.1*	*-5.1*	*22.3*	*12.9*	*1.2*	*10.5*	*10.5*	*100*
Overall	*0.6*	*-12.6*	*-4.7*	*-4.5*	*20.5*	*12.6*	*1.0*	*9.8*	*9.8*	*100*

3 (removal of the a-recycle), which improved the denitrification performance and reduced the nitrate recycle to the anaerobic reactor. It should further be noted that the overall average of ~59 mgN/d (~3 mgN/l influent) NO_X denitrified in the anaerobic reactor (as noted from Table 3.6a and b in Section 3.3.2.1) will have negatively affected the overall average P removal by using ~24 mgCOD/l RBCOD to denitrify that nitrate in the anaerobic reactor, RBCOD which would otherwise have been available for P release.

From Figure 3.16 it can be seen that most of the P release occurred in the anaerobic reactor, as expected. However, some release occurred in the internal settler A and surprisingly some release also occurred in the external nitrification system. From Table 3.8, an overall average of 57.8% of the total P release in the system occurred in the anaerobic reactor, 21.6% in internal settler A, and 20.6% in the external nitrification system. The fact that the P release continued in the internal settler A is of no concern; indeed, it is beneficial that it augments the anaerobic reactor P release. In a modification of the DEPHANOX external nitrification system, the anaerobic reactor and internal settler are combined in a single clarigester type reactor allowing accumulation of sludge, P release and settlement simultaneously (Bortone *et al.*, 1997).

The P release in the aerobic external nitrification reactor is not beneficial to BEPR. It is unlikely that this P release is coupled with SCFA uptake by PAOs as in the anaerobic reactor. It is more likely (i) a P release through endogenous decay of PAOs that do not settle in the internal settler A and enter the external nitrification system or (ii) a breakdown in the external nitrification system of filterable (because this P does not reflect in the filtered P of the internal settler supernatant) but non settleable (because it does not settle out in internal settler A) organics containing P. Of the two, the former is less likely because PAOs are strongly flocculent and readily settle out, which leaves the latter as the most likely cause. However, which organic compounds contain up to 5 mgP/l influent that are non-settleable but filterable are not known. For the evaluation of the BEPR in the system of this investigation, only the P released in the anaerobic reactor and internal settler A was considered. The ~5 mgP/l influent P release in the EN system requires that an additional 5 mgP/l influent P uptake take place in the anoxic and aerobic reactor before P is removed.

It can be seen from Figure 3.16 that a large mass of P uptake took place in the main anoxic reactor (61.9% of the overall average P uptake) with the remainder taking place in the main aerobic reactor (about 38.1% of the overall average). A negligible amount of P uptake occurred in the final settler, and the pre-anoxic reactor showed negligible P uptake or release, except if a high mass of nitrate was recycled to it, when it showed a small but still negligible P uptake. The very high anoxic P uptake is characteristic of ENBNRAS systems (Hu *et al.*, 1999; Moodley *et al.*, 1999) and will be discussed in more detail in Section 3.3.3.3 below.

The overall average P removal of 9.8 mgP/l influent in this system compares very well with those found by Hu *et al.* (1999) and Moodley *et al.* (1999) for their ENBNRAS systems - being 8.8 mgP/l influent for an average influent COD of 717 mgCOD/l and 10.4 mgP/l influent for an average influent COD of 691 mgCOD/l respectively for the same Mitchells Plain wastewater source. The overall average system P removal of 9.8 mgP/l influent also compares well with those obtained from investigations on BNRAS systems that showed significant anoxic phosphorus uptake (Table 3.9).

TABLE 3.9 - System P removals for previous laboratory scale investigations, all for the same Mitchells Plain wastewater source.

Researcher	Influent COD	Average P Removal	System
Musvoto *et al.* (1992)	956 mgCOD/l	12.2 and 11.3 mgP/l influent	UCT (both @ 20°C)
Pilson *et al.* (1995)	990 mgCOD/l	12.0 and 10.7 mgP/l influent	UCT (@ 20°C and 12°C)
Mellin *et al.* (1998)	727 mgCOD/l	11.4 mgP/l influent	UCT (@ 30°C)
Hu *et al.* (1999)	717 mgCOD/l	8.8 mgP/l influent	ENBNRAS (@ 20°C)
Moodley *et al.* (1999)	691 mgCOD/l	10.4 mgP/l influent	ENBNRAS (@ 20°C)
This investigation	736 mgCOD/l	9.8 mgP/l influent	ENBNRAS (@ 20°C)

At higher influent COD concentrations and therefore higher influent RBCOD concentrations, higher P removals than at 750 mgCOD/l are expected, and therefore for those investigations with ~1000 mgCOD/l influent, higher P removals than with 750 mgCOD/l are observed.

Figure 3.17 shows the system P removal and effluent P stacked above each other to make up the influent total P (TP) concentration. On average, 40% of the influent TP was removed. This may not seem high, but it should be noted that the influent sewage was augmented with approximately 10 mgP/l orthophosphate to intentionally keep the P concentrations in the effluent high. This was done to ensure that P did not become limiting.

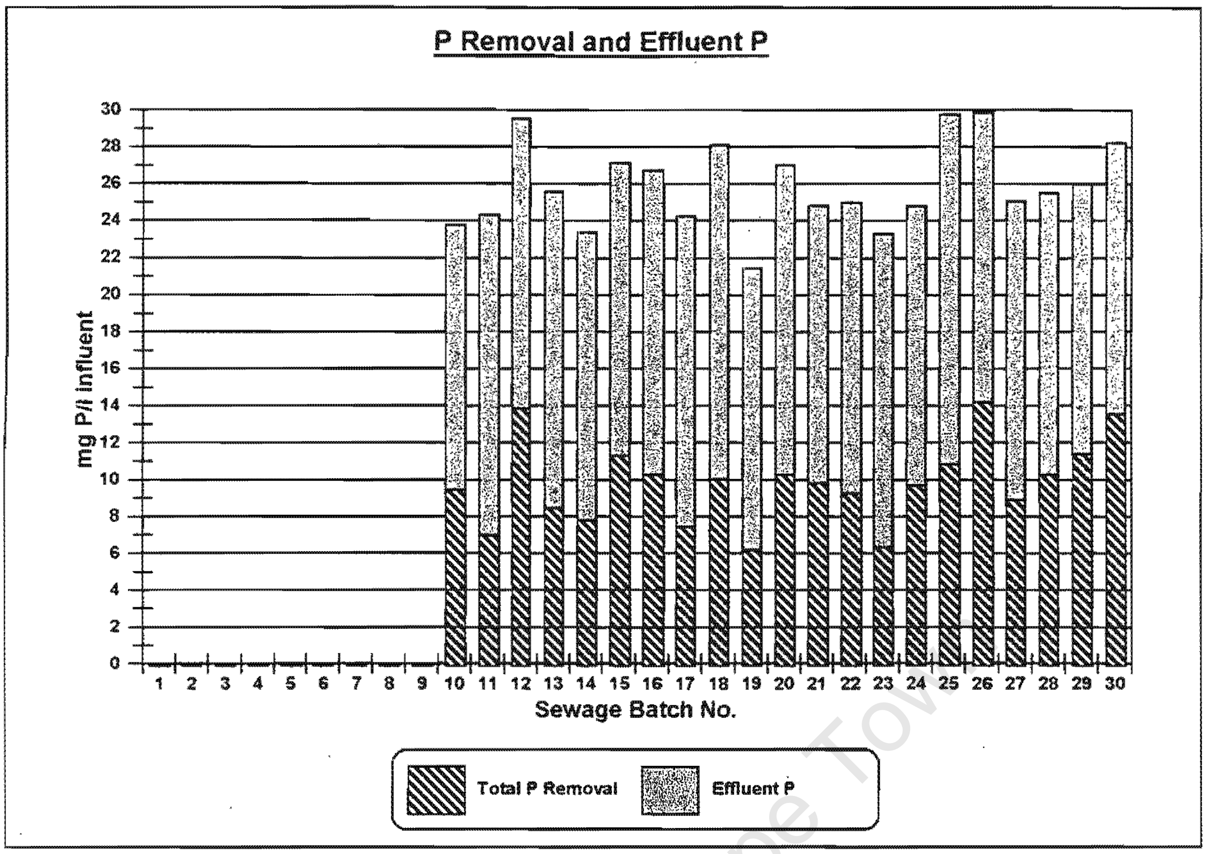

FIGURE 3.17 - Average effluent P concentrations and system P removals for sewage batches 10 to 30.

3.3.3.2 Comparison of measured and calculated P removal

The BEPR performance of the ENBNRAS system was assessed by comparing the observed P removal with that theoretically calculated from the steady state model of Wentzel *et al.* (1990). The procedure for calculating the theoretical BEPR is given in detail by Mellin *et al.* (1998) and in summary by Ekama and Wentzel (1999). The procedure 'fractionates' the measured VSS mass in the system into active ordinary heterotrophic (OHO) and polyphosphate accumulating (PAO) organisms, OHO and PAO endogenous residue masses and the unbiodegradable particulate material from the influent, viz. $X_{B,H}$, $X_{B,G}$, $X_{E,H}$, $X_{E,G}$ and X_I respectively, by reconciling the theoretically calculated VSS mass with that measured. The unbiodegradable soluble COD fraction ($f_{S,US}$) is calculated from the filtered effluent to total influent COD concentration ratio (i.e. $f_{S,US} = S_{te}(filt.)/S_{ti}$) and the unbiodegradable particulate COD fraction of the wastewater ($f_{S,UP}$), which defines the X_I component of the VSS, is varied until the calculated VSS mass is equal to the measured VSS mass. Once the correct $f_{S,UP}$ is found, the theoretical removal is matched to that measured by varying the P content of the PAO's ($f_{XBG,P}$) for fixed P content of the other four VSS components at 0.03 mgP/mgVSS. See Appendix C for more details on this procedure.

Tables 3.10a and 3.10b list the results obtained from the above procedure. In Table 3.10a the COD was adjusted for the COD fraction consumed (lost to the main system) in the external nitrification system without changing the influent RBCOD concentration, and in Table 3.10b the COD was adjusted for both the COD fraction utilized in the external nitrification system and for the fraction of COD that was unaccounted for in the COD mass balance, again without changing the influent RBCOD concentration. By keeping the influent RBCOD concentration constant at that measured, in effect the COD lost in the EN reactor was subtracted from the slowly biodegradable (SB) COD fraction. Because the COD mass balance was only around 80%, the influence of this 20% unaccounted for COD on the results was examined by subtracting also this COD from the influent COD. As the influent RBCOD concentration was also maintained at that measured for this evaluation, the 20% unaccounted for loss of COD was also in effect subtracted from the SBCOD. Because of the consistency with which low COD mass balances have been observed in NDBEPR systems, some simulation models for these systems include a 15 to 20% COD loss in fermentation processes in the anaerobic reactor to take account of this loss. An anaerobic hydrolysis of SBCOD to RBCOD is introduced also to 'restore' the influent RBCOD concentration to around its measured value, otherwise the P removal would not be correctly predicted.

Tables 3.11a and 3.11b show the results when, instead of searching for an $f_{S,UP}$ value that matches the calculated and measured VSS masses, a fixed $f_{S,UP}$ of 0.130 is assumed, again with compensation for the COD fraction lost in the external nitrification system (Table 3.11a), and the COD fraction lost in the external nitrification system together with the unaccounted COD fraction (Table 3.11b) respectively, while not changing the influent RBCOD concentration. This was done to compare the calculated VSS with the measured VSS when a fixed $f_{S,UP}$ is assumed for the wastewater.

TABLE 3.10a - Calculated $f_{s,up}$ and $f_{xbg,p}$ fractions using the Wentzel *et al.* (1990) BEPR model. (Compensated for COD loss in EN system only.)

CONSTANTS:

Temp. =	20	deg. C
Q_i =	20	l/d
R_s =	10	d
s-recycle =	1	ratio w.r.t Q_i
f_{xa} =	0.25	(anaerobic mass fraction)

Y_H =	0.45	mgVSS/mgCOD	K_{c20} =	0.06	1/d
b_{H20} =	0.24	1/d	Y_G =	0.45	mgVSS/mgCOD
f =	0.2		b_{G20} =	0.04	1/d
			$f_{EP,G}$ =	0.25	mgVSS/mgVSS
			$f_{xbg,p}$ =	0.03	mgVSS/mgVSS
			$f_{al,p}$ =	0.03	mgVSS/mgVSS
			$f_{xbh,p}$ =	0.03	mgVSS/mgVSS
			$f_{xeh,p}$ =	0.03	mgVSS/mgVSS

BATCH	Influent S_{ti} mgCOD/l	Floc. Fil Influent mgCOD/l	Fil. Eff. S_{ute} mgCOD/l	RBCOD S_{bsi} mgCOD/l	f_{sup}	S_{bi} mgCOD/l	COD fraction lost in Nitrifier	S'_{bi} mgCOD/l	$NO2_r$ mgN/l	$NO3_r$ mgN/l	S'_{bsi} mgCOD/l	$M_{XB,H}/Q$	$S_{bs,N}$	MS_{seq} mgCOD/d
1	757.33	200.00	41.43	158.57	0.021	700.17	0.0984	625.67	0.16	2.19	138.94	674.55	11.46	2320.12
2														
3														
4	787.92	211.13	52.61	158.52	0.077	674.59	0.3658	386.35	1.92	8.20	95.60	415.56	11.61	1447.55
5	809.77	170.76	41.44	129.32	0.105	504.55	0.2825	332.30	1.12	10.05	37.29	402.73	4.64	560.30
6	748.75	218.90	47.22	171.68	0.058	656.23	0.2897	439.88	0.00	1.08	162.39	419.13	19.60	2464.00
7	694.71	143.48	45.29	98.19	0.087	588.89	0.2861	390.13	0.47	1.74	80.88	434.45	9.50	1237.68
8	768.08	185.47	56.45	129.02	0.006	704.96	0.3171	462.03	3.48	4.80	70.34	536.94	7.00	1126.95
9														
10	799.38	175.68	51.66	124.02	-0.120	843.65	0.1876	693.69	0.24	0.63	117.40	785.29	8.52	2007.23
11	783.11	166.53	54.72	111.81	-0.050	787.74	0.1163	676.69	3.96	3.06	65.69	820.63	4.59	1130.26
12	764.70	168.41	40.55	127.86	-0.010	732.07	0.1016	654.35	0.24	7.95	58.29	799.93	4.16	899.24
13	784.83	151.31	45.90	105.41	-0.023	757.04	0.1506	638.86	0.52	10.25	14.66	828.83	1.02	252.57
14	715.39	163.29	34.07	129.22	-0.002	682.48	0.2314	516.95	0.30	5.47	80.68	596.91	7.37	1318.95
15	727.66	195.56	45.41	150.15	-0.034	707.11	0.2322	538.15	0.37	10.34	59.38	647.10	5.07	884.64
16	758.78	195.95	34.85	161.1	0.025	704.72	0.2451	518.74	0.35	0.68	153.50	524.58	15.55	2447.86
17	664.32	159.91	40.45	119.46	0.080	570.58	0.1977	439.22	0.58	0.84	109.34	468.66	12.11	1702.39
18	757.77	200.60	35.47	165.13	0.004	719.07	0.2185	553.52	0.04	0.15	163.64	557.80	15.76	2641.42
19	684.95	202.88	45.46	157.42	0.069	592.14	0.1617	481.40	0.67	3.13	127.15	504.06	13.30	2011.07
20	760.92	176.21	35.46	140.75	0.080	680.13	0.1879	537.17	0.02	0.03	140.39	560.83	13.48	2268.52
21	749.07	197.60	40.56	157.04	0.057	686.00	0.1634	543.59	0.02	0.04	156.60	552.49	15.22	2523.04
22	718.01	181.57	37.43	144.14	0.066	633.00	0.1877	498.20	0.29	0.22	140.80	511.57	14.56	2233.78
23	722.27	173.53	35.01	138.52	-0.016	699.07	0.1792	569.67	0.58	3.22	107.93	635.89	9.35	1784.41
24	713.77	176.72	39.82	136.9	0.056	633.76	0.1325	539.19	0.64	0.28	131.48	572.51	12.42	2132.61
25	759.67	222.59	39.90	182.69	0.053	679.15	0.1617	556.34	0.03	0.02	182.37	542.56	17.99	2927.86
26	708.76	174.82	37.45	137.37	0.157	560.13	0.2100	411.32	0.04	0.07	136.57	408.15	16.81	2058.80
27	711.19	195.51	36.69	158.82	0.170	553.86	0.1849	422.35	0.03	0.04	158.33	401.87	19.73	2377.35
28	734.11	174.60	38.56	136.04	0.108	616.15	0.1604	498.42	0.58	1.32	121.78	530.85	12.22	1946.79
29	738.10	181.15	36.24	144.91	0.057	660.14	0.1806	526.83	0.04	0.13	143.59	544.61	14.12	2307.03
30	747.81	196.02	39.50	156.52	0.023	690.88	0.1098	608.77	0.06	0.10	155.36	635.75	13.47	2568.51
Avg.	735.81	183.71	41.84	141.87	0.040	665.88	0.20	520.73	0.62	2.74	115.20	567.19	11.51	1843.74

BATCH	$MX_{B,G}$ mgVSS	$MX_{E,G}$ mgVSS	$MS_{B,H}$ mgCOD/d	$MX_{B,H}$ mgVSS	$MX_{E,H}$ mgVSS	f_{cv} mgCOD/mgVSS	MX_I mgVSS	MX_v Calc. mgVSS	MX_v Measured mgVSS	$f_{xbg,p}$*	ΔP_G mgP/l inf.	ΔP_H mgP/l inf.	ΔP_I mgP/l inf.	ΔP_T Calc. mgP/l inf.	ΔP_T Measured mgP/l inf.
1	7457.53	745.75	10193.28	13491.10	6475.73	1.38	2287.13	30457	30457	0.32	11.93	3.00	0.34	15.27	15.27
2															
3															
4	4652.83	465.28	6279.53	8311.14	3989.35	1.32	9173.83	26592	26592	0.20	4.64	1.85	1.38	7.86	7.86
5	1800.96	180.10	6085.69	8054.59	3866.20	1.30	9835.30	23737	23737	0.05	0.46	1.79	1.48	3.73	3.73
6	7920.01	792.00	6333.58	8382.87	4023.68	1.35	6408.88	27527	27526	0.27	10.80	1.86	0.96	13.63	13.62
7	3978.24	397.82	6565.02	8688.99	4170.72	1.23	9864.07	27100	27100	0.39	7.79	1.93	1.48	11.20	11.20
8	3622.35	362.24	8113.74	10738.77	5154.61	1.23	781.28	20639	20640	0.23	4.16	2.38	0.11	6.66	6.66
9															
10	6451.82	645.18	11866.59	15705.78	7538.78	1.41	-13623.72	16718	16717	0.25	8.11	3.49	-2.04	9.56	9.56
11	3833.04	383.30	12403.61	16416.54	7879.94	1.54	-5105.51	23187	23188	0.22	4.14	3.64	-0.77	7.01	7.01
12	3211.86	321.19	12087.82	15998.59	7679.32	1.28	-1240.42	25971	25971	0.86	10.58	3.55	-0.19	13.95	13.96
13	811.83	81.18	12524.59	16576.67	7956.80	1.47	-2500.07	22926	22926	1.28	9.23	3.68	-0.38	8.53	8.53
14	4239.47	423.95	9020.03	11938.28	5730.37	1.37	-168.96	22163	22163	0.24	5.21	2.65	-0.03	7.83	7.83
15	3184.81	318.49	9778.37	12941.96	6212.14	1.42	-3507.45	19128	19128	0.57	6.99	2.87	-0.53	11.34	11.34
16	7868.13	786.81	7926.98	10491.59	5035.96	1.47	2620.78	26803	26804	0.19	7.58	2.33	0.39	10.31	10.31
17	5471.98	547.20	7082.01	9373.25	4499.16	1.48	7210.23	27102	27102	0.16	4.34	2.08	1.08	7.50	7.50
18	8490.27	849.03	8429.06	11156.10	5354.93	1.42	454.74	26305	26305	0.17	7.54	2.48	0.07	10.09	10.08
19	6464.17	646.42	7616.91	10081.20	4838.98	1.46	6471.91	28503	28503	0.09	3.02	2.24	0.97	6.23	6.23
20	7291.67	729.17	8474.82	11216.67	5384.00	1.43	6352.53	30974	30973	0.19	6.94	2.49	0.95	10.38	10.38
21	8109.76	810.98	8348.81	11049.80	5303.95	1.47	5765.76	31040	31040	0.16	6.60	2.45	0.86	9.92	9.91
22	7178.94	717.89	7730.32	10231.31	4911.03	1.41	6727.13	29767	29768	0.16	6.00	2.27	1.01	9.28	9.28
23	5735.59	573.56	9609.01	12717.80	6104.55	1.40	-1687.70	23444	23444	0.13	3.83	2.82	-0.25	6.40	6.40
24	6854.82	685.48	8651.26	11450.20	5496.10	1.39	5792.70	30279	30280	0.18	6.38	2.54	0.87	9.79	9.79
25	9410.99	941.10	8198.94	10851.54	5208.74	1.41	5743.41	32156	32156	0.16	7.58	2.41	0.86	10.85	10.84
26	6617.57	661.76	6167.63	8163.03	3918.26	1.37	16181.95	35543	35542	0.30	10.03	1.81	2.43	14.27	14.28
27	7641.50	764.15	6069.60	8033.30	3855.98	1.45	16584.48	36879	36880	0.12	4.70	1.78	2.49	8.97	8.97
28	6257.52	625.75	8021.71	10616.97	5096.15	1.45	10950.55	33547	33547	0.20	6.32	2.36	1.64	10.32	10.31
29	7415.44	741.54	8229.66	10892.20	5228.26	1.47	5676.84	29954	29954	0.22	8.15	2.42	0.85	11.42	11.42
30	8255.94	825.59	9606.87	12714.97	6103.19	1.44	2421.03	30321	30320	0.25	10.41	2.82	0.36	13.60	13.60
Avg.	5926.30	592.63	8570.94	11343.89	5445.07	1.40	4053.73	27361.82	27361.70	0.20	6.72	2.52	0.61	9.85	9.85

*Average does not include the outliers (shaded).

From Table 3.10b, which lists the results obtained by the same procedure and taking account of the COD lost in the external nitrification system as well as the COD not accounted for in the COD balance, it can be seen that the $f_{S,UP}$ varies between 0.04 and 0.24 with an average of 0.126. These values are much more realistic, include no negative values and are close to the $f_{S,UP}$ values obtained in non BEPR systems (i.e. fully aerobic and N removal only), viz. 0.11 to 0.13 for the same Mitchells Plain wastewater (Warburton *et al.*, 1991; Mbewe *et al.*, 1995 and Ubisi *et al.* 1997). The $f_{XBG,P}$ varies between 0.05 and 0.41 mgP/mgPAOAVSS, with an average of 0.23 mgP/mgPAOAVSS omitting the same 'outlier' $f_{XBG,P}$ values as earlier (sewage batches 12,13 and 15). Figures 3.18 to 3.21 show these values graphically, for sewage batches 1 to 30.

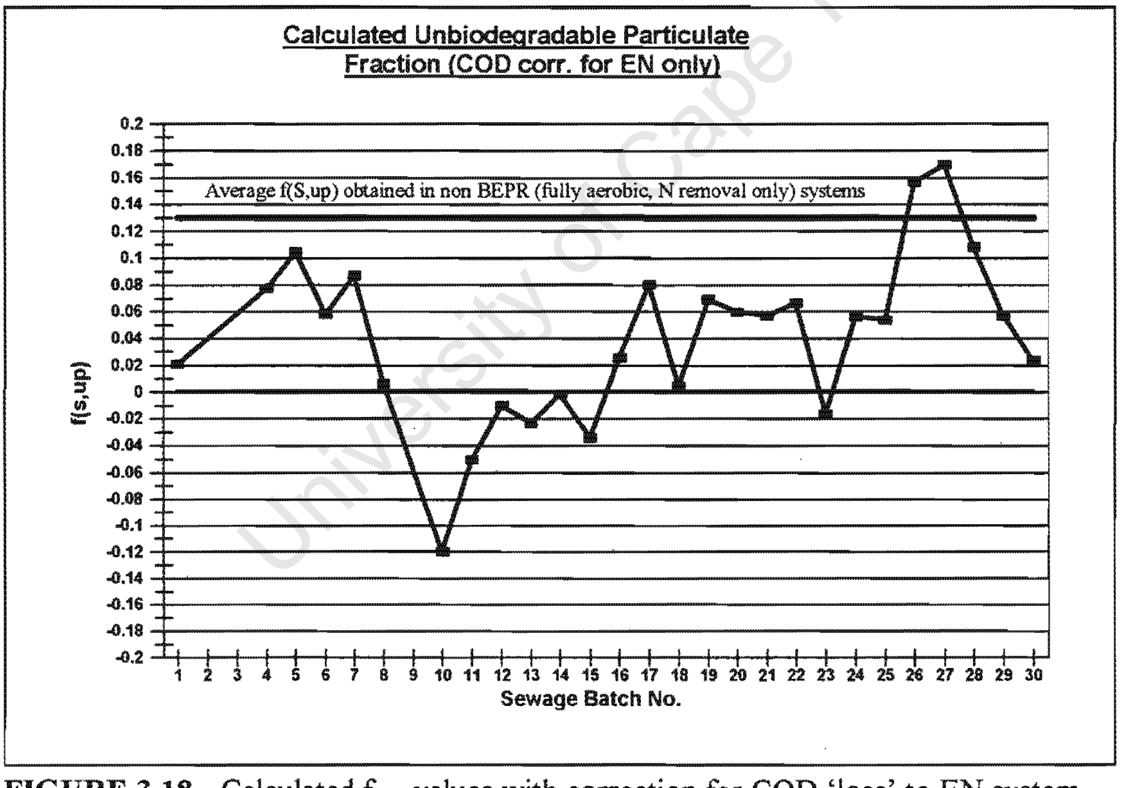

FIGURE 3.18 - Calculated $f_{s,up}$ values with correction for COD 'loss' to EN system only, for sewage batches 1 to 30.

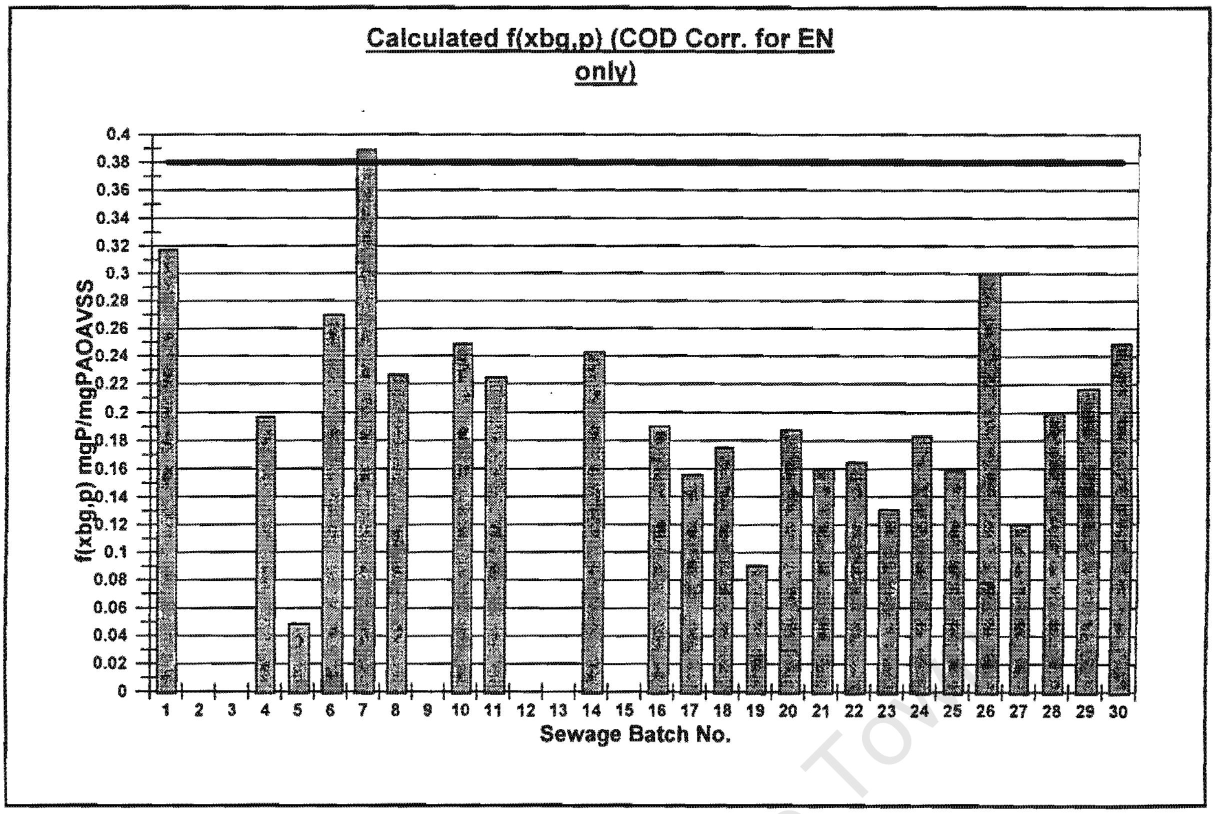

FIGURE 3.19 - Calculated $f_{xbg,p}$ values with correction for COD 'loss' to EN system only, for sewage batches 1 to 30.

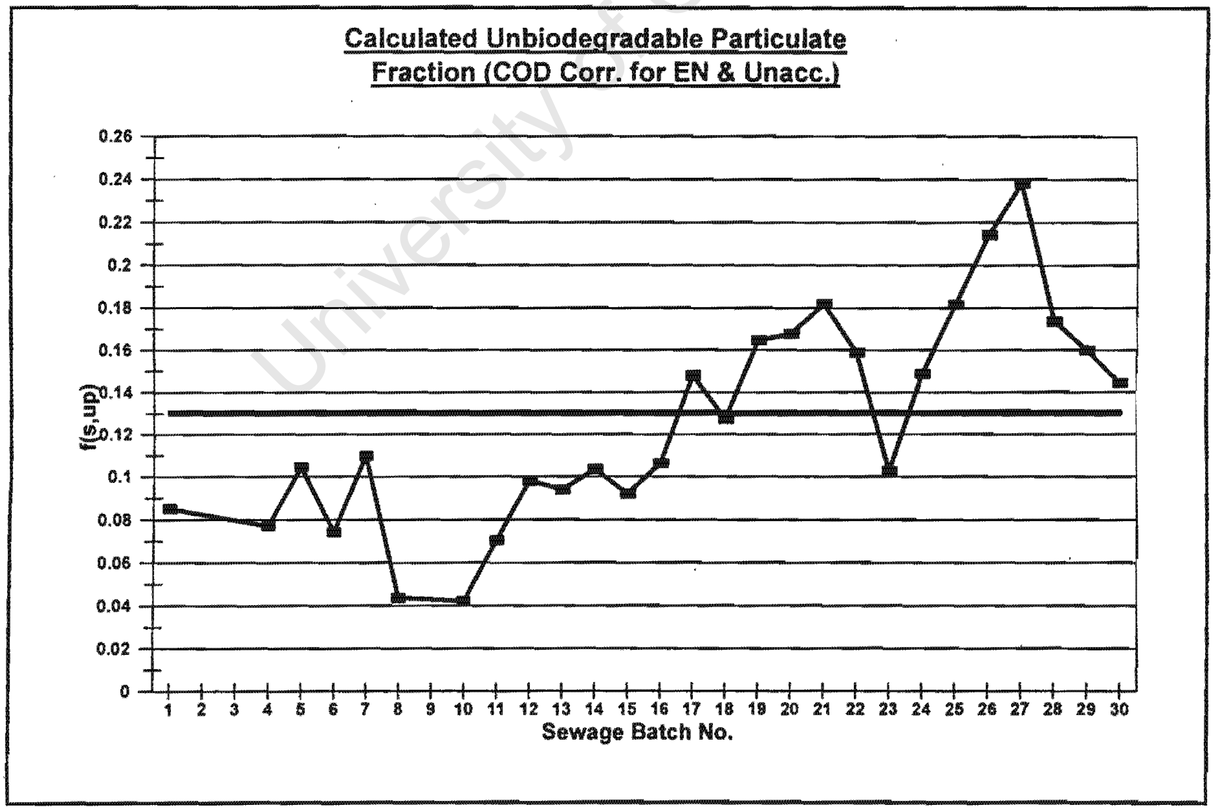

FIGURE 3.20 - Calculated $f_{s,up}$ values with correction for COD 'loss' to EN system and COD unaccounted for, for sewage batches 1 to 30.

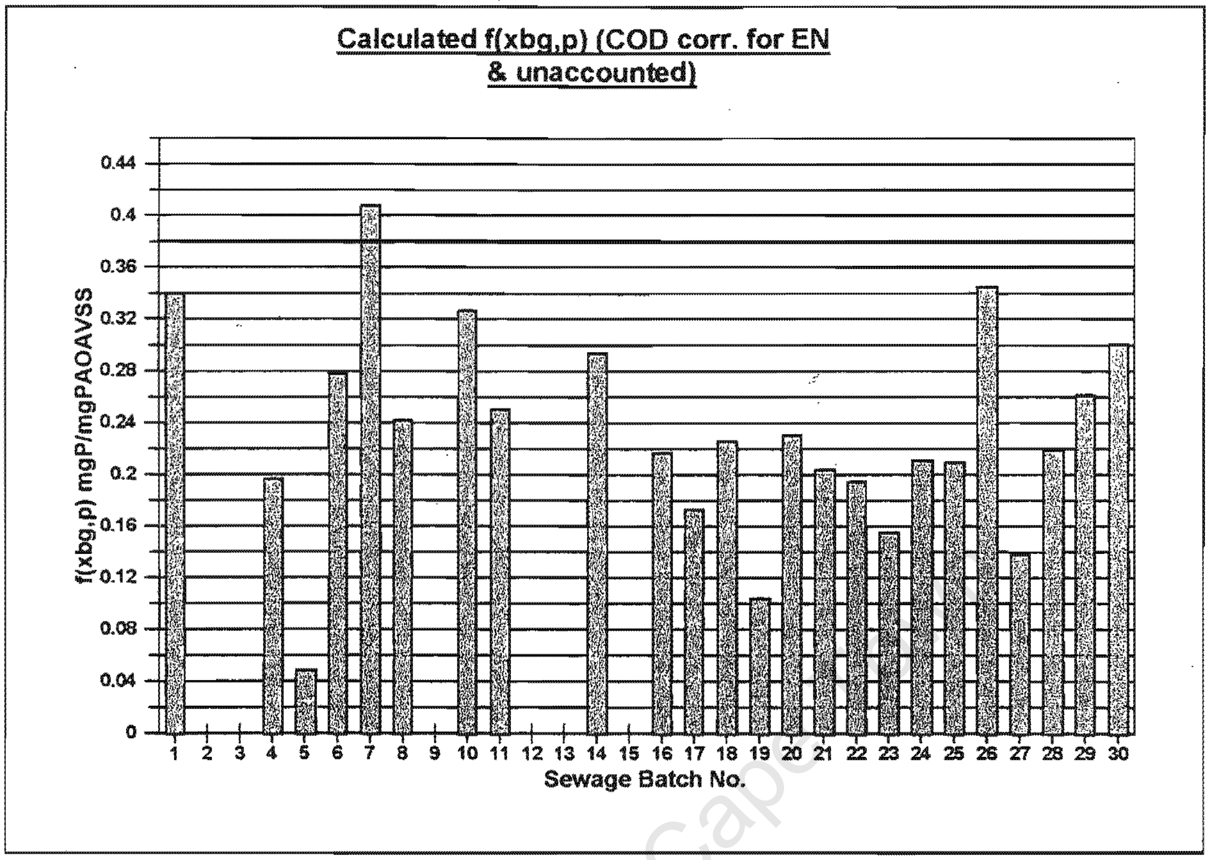

FIGURE 3.21 - Calculated $f_{xbg,p}$ values with correction for COD 'loss' to EN system and COD unaccounted for, for sewage batches 1 to 30.

As mentioned above, for the predominantly (>95%) aerobic P uptake BEPR behaviour the steady state model of Wentzel *et al.* (1990) gives a $f_{XBG,P}$ value of 0.38 mgP/mgPAOAVSS and the $f_{S,UP}$ value for Mitchells Plain raw sewage was found to be around 0.13 in previous non BEPR laboratory scale systems run in the University of Cape Town laboratory (Warburton *et al.*, 1991; Mbewe *et al.*, 1995 and Ubisi *et al.*, 1997). The average $f_{S,UP}$ for the ENBNRAS system of this investigation of 0.040 for the calculations taking account only of the COD 'lost' in the external nitrification system does not compare well, the $f_{S,UP}$ value being very much lower than 0.13. The averages from the calculations taking account of the COD lost in the nitrification system as well as the COD not accounted for in the COD mass balance, i.e. 0.126, compares more favourably and is closer to that expected for the Mitchells Plain wastewater. This gives credibility to the hypothesis stated in Section 3.3.1 above, that the COD fraction unaccounted for is utilized by unknown processes that are not taken into account in the COD mass balance. The fact that the calculations which take account of the unaccounted for COD give more realistic $f_{S,UP}$ values, suggests that this fraction is indeed not utilized by the OHO and PAO organisms in the system, but is used by other biological processes before it can be used by these organisms. This can also be seen from Tables 3.11a and 3.11b, where a fixed $f_{S,UP}$ value of 0.13 was used to check the differences between the calculated and measured VSS.

The $f_{XBG,P}$ values obtained from previous investigations on NDBEPR systems with predominantly aerobic P uptake BEPR (Clayton *et al.*, 1991; Sneyders *et al.*, 1998 - 0.388 and 0.471 mgP/mgPAOAVSS respectively, see Table 3.12) are significantly higher than those obtained from similar investigations with anoxic/aerobic P uptake BEPR (Musvoto *et al.*, 1992; Kaschula *et al.*, 1993; Pilson *et al.*, 1995; Mellin *et al.*, 1998 - averages of 0.129, 0.135, 0.117 and 0.247 mgP/mgPAOAVSS respectively, see Table 3.12). Similarly low $f_{XBG,P}$ values were found for ENBNRAS systems exhibiting significant anoxic P uptake in the investigations of Hu *et al.* (1999) and Moodley *et al.* (1999) where the $f_{XBG,P}$ values obtained were 0.195 and 0.312 mgP/mgPAOAVSS respectively, and Moodley *et al.* (1999) obtained a $f_{S,UP}$ of 0.11 (see Table 3.12). The $f_{XBG,P}$ values from this system are closer to those obtained by Mellin *et al.* (1998) and Hu *et al.* (1999), for both the above calculations and higher than those obtained by Musvoto *et al.* (1992), Kaschula *et al.* (1993) and Pilson *et al.* (1995). The $f_{S,UP}$ value of 0.11 obtained by Moodley *et al.* (1999) is substantially higher than the 0.040 obtained for this system from the calculation taking only the COD 'loss' in the external nitrification system into account, but closer (albeit lower) to the value of 0.126 obtained from the calculations taking the COD lost in the external nitrification system and the COD unaccounted for into consideration.

The $f_{XBG,P}$ values obtained for this system (0.20 and 0.23 mgP/mgPAOAVSS) are quite close together, and roughly 40% less than the 0.38 of the steady state model of Wentzel *et al.* (1990). In practice this does not necessarily mean that the PAO's in the ENBNRAS system can store 40% less P than those in the BNRAS systems with >95% aerobic phosphorus uptake. It may be an indication that the yield of these anoxic PAO's is less than that for aerobic PAO's, effectively resulting in a lower PAO mass (with similar P content as aerobic PAO's) and hence lower TP removal (in the calculation procedure to determine $f_{XBG,P}$, it is assumed that the aerobic PAO yield applies to all PAOs). The $f_{S,UP}$ value of 0.040 and 0.126 for the two calculations indicates that the total VSS of the system is lower than the theory would predict, and that the calculated $f_{S,UP}$ value is very sensitive to fluctuations in the measured VSS.

3.3.3.3 Phosphorus uptake

When the BEPR model was initially developed (1980s), it was observed that P uptake takes place predominantly under aerobic conditions. However, anoxic P uptake has been increasingly reported in the past 6 years (Kern-Jespersen and Henze, 1993; Kuba *et al.*, 1993) in BNR systems. Anoxic P uptake was also found to take place in conventional laboratory scale BNRAS systems (Ekama and Wentzel, 1999) and at full scale (Kuba *et al.*, 1997). The process of anoxic P uptake is not yet fully understood, but it is believed that certain PAO groups have the ability to utilize nitrate instead of oxygen as an electron acceptor, to utilize a part of their stored PHB in the anoxic zone and hence effecting anoxic P uptake. Ekama and Wentzel (1999) noted that BEPR with P uptake under anoxic conditions is about a third lower than aerobic uptake BEPR. This results in a lower TP removal performance for the same RBCOD taken up in the anaerobic reactor by systems that exhibit significant anoxic P uptake (see Table 3.13).

TABLE 3.13 - Total P removal achieved from previous laboratory scale investigations.

Researcher	Infl. COD Conc.	TP Removal	% Anoxic P Uptake	System
Clayton *et al.* (1991)	1000 mgCOD/l	21 mgP/l influent	5%	UCT (@ 20°C)
Musvoto *et al.* (1992)	956 mgCOD/l	12.2 and 11.3 mgP/l influent	27% and 47%	UCT (both @ 20°C)
Pilson *et al.* (1995)	990 mgCOD/l	12.0 and 10.9 mgP/l influent	47% and16%	UCT (@ 20°C and 12°C)
Mellin *et al.* (1998)	727 mgCOD/l	11.4 mgP/l influent	29%	UCT (@ 30°C)
Sneyders *et al.* (1998)	683 and 830 mgCOD/l	13.1 and 16.8 mgP/l influent	0% and 0%	UCT (both @ 20°C)
Hu *et al.* (1999)	717 mgCOD/l	8.8 mgP/l influent	52%	ENBNRAS (@20°C)
Moodley *et al.* (1999)	691 mgCOD/l	10.4 mgP/l influent	66%	ENBNRAS (@20°C)
This investigation	736mgCOD/l	9.8 mgP/l influent	62%	ENBNRAS (@20°C)

A similar BNRAS system that exhibits no anoxic uptake would remove about 16 mgP/l influent - for example Sneyders *et al.* (1998) found a TP removal of 16.8 mgP/l for an influent COD concentration of 830 mgCOD/l (see Table 3.13). On average, the three ENBNRAS systems removed about 40% less P than would be expected from a similar BNRAS system with no anoxic P uptake. A direct comparison between aerobic P uptake BEPR in a UCT system and the anoxic P uptake BEPR in the system of this investigation is given by Vermande *et al.* (2000) and is reviewed in Section 3.5 below.

Hu *et al.* (1999) reported an average anoxic P uptake of about 50%. Moodley *et al.* (1999) reported about 66%. The system of this investigation showed an average of about 62% anoxic P uptake. From this it can be seen that anoxic P uptake is inherent to the ENBNRAS systems and will account for more than half of the total P uptake in the system. Figure 3.22 below shows the average percentage anoxic and aerobic P uptake observed in this investigation during sewage batches 10 to 30.

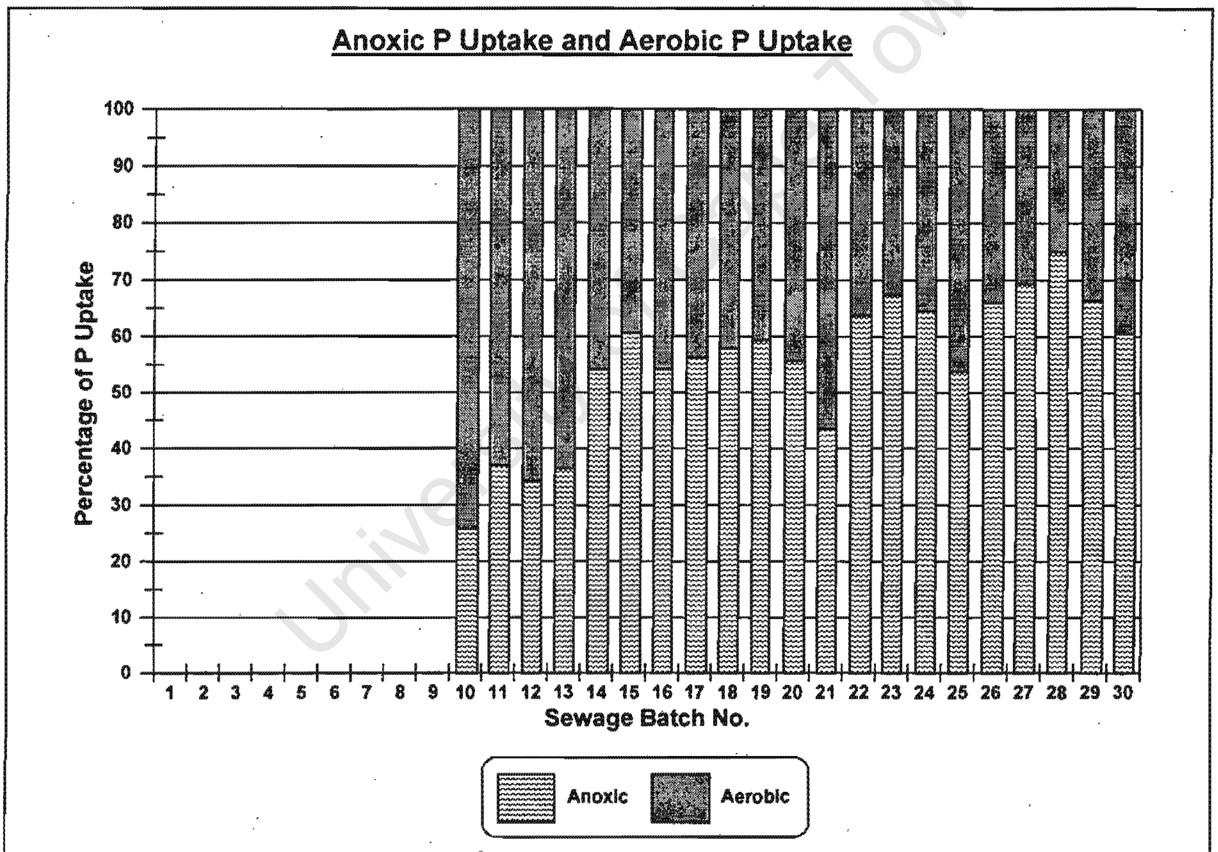

FIGURE 3.22 - Percentage anoxic and aerobic P uptake for sewage batches 10 to 30.

Figure 3.22 shows that the lowest % anoxic P uptake was 26% for sewage batch 10, and the highest was 75% for sewage batch 28. The general trend was one of a slow but steady increase in the % anoxic P uptake over time. The initial low percentage corresponds to the period of poor nitrate denitrification performance of the system after the toxic batch of sewage (batch 9). As the system and the denitrification performance recovered, the anoxic P uptake gradually increased and indicates that the anoxic P uptake is connected to the denitrification performance of the anoxic reactor. Since the anoxic P uptake gradually increased throughout sewage batches 10 to 30, it is difficult to state how much was due to the recovery of the system, and how much was due to the natural development of the anoxic P uptake while the system was moving towards a steady state scenario. However, it is reasonable to assume that the former reason dominated over sewage batches 10 to 15, while the latter was more dominant in sewage batches 16 to 30.

Figure 3.23 below shows a plot of % anoxic P uptake versus total P released and TP removed in the system. This figure helps to establish whether an increase in the % anoxic P uptake has a noticeable impact on the P removal by the system.

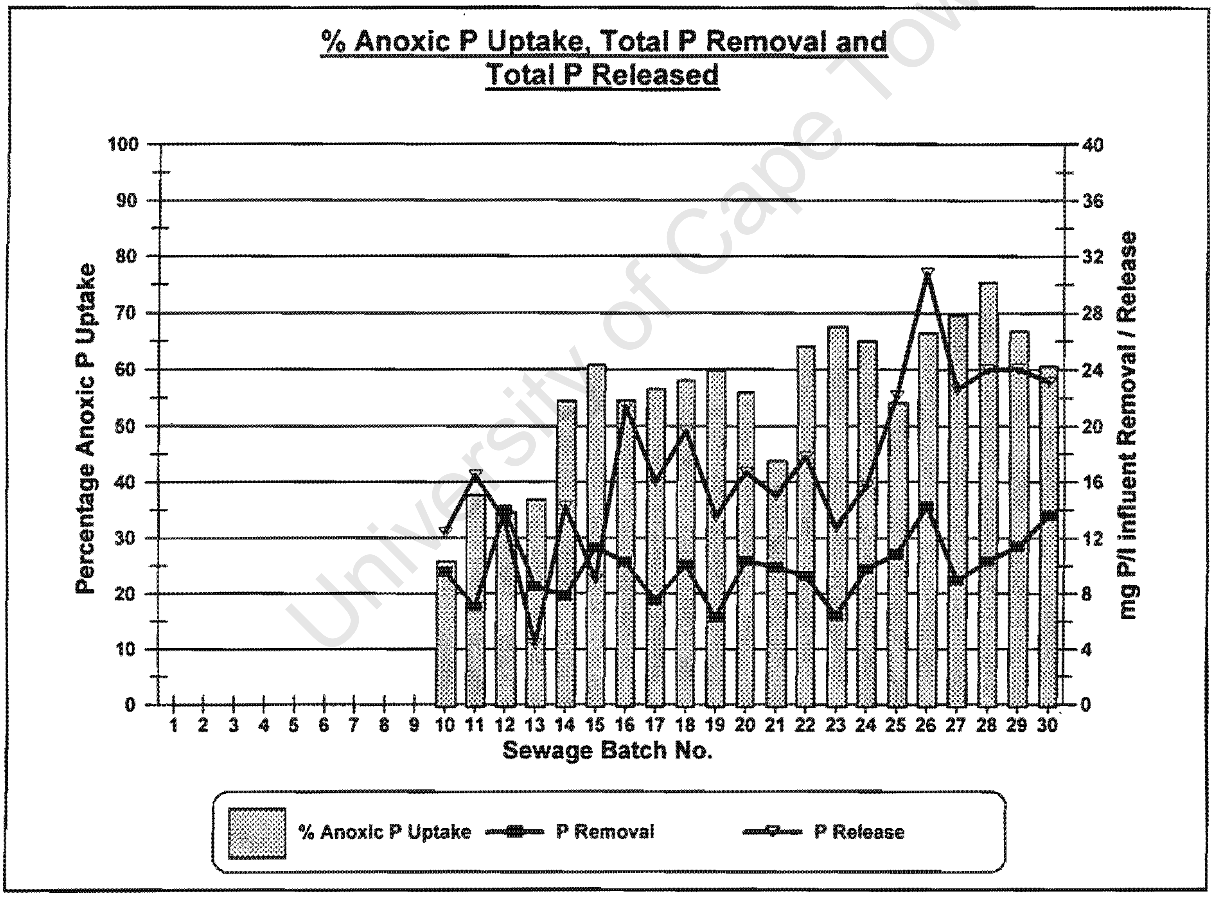

FIGURE 3.23 - Percentage anoxic P uptake, P release and P removal for sewage batches 10 to 30.

From Figure 3.23 it can be seen that the P removal remained relatively constant while the % anoxic P uptake gradually increased with time. Using the two extremes for illustration, the P removal for sewage batch 10 with an anoxic P uptake of 26% was about 9.6 mgP/l influent, and that for sewage batch 28 with an anoxic P uptake of 75% was about 10.3 mgP/l influent. The P removal in fact follows the P release trend much more closely than the percentage anoxic P uptake trend. However, the increase in P release between sewage batches 10 and 30 did not result in a concomitant significant increase in P removal as would be expected. This indicates that the system P removal was more dependant on the P release (viz. influent RBCOD concentration and nitrate recycled to the anaerobic reactor) than on the % anoxic P uptake. If the anoxic P uptake BEPR is about 30% less efficient than aerobic P uptake BEPR, the P removal in sewage batch 10 should have been larger than that in sewage batch 28. It seems that the two processes together compensated each other in the period between sewage batch 10 and 30. Over this period, the % anoxic P uptake increased gradually from about 26% to about 75%. At the same time the P release showed a similar increase. Since the P removal of the system remained fairly constant at around 10.0 mgP/l over this period, it is reasonable to assume that the expected increase in P removal due to the increase in P release was masked by a simultaneous reduction in P removal as the P uptake shifted from being predominantly aerobic P uptake in sewage batch 10, to being predominantly anoxic P uptake in sewage batch 30. This confirms that as the P uptake shifts from aerobic P uptake to anoxic P uptake, a reduction in the P removal performance can be expected.

It has been hypothesised by Ekama and Wentzel (1997), that the anoxic P uptake is dependant on the anoxic/aerobic mass fraction proportions and the nitrate load on the anoxic reactor. The larger the anoxic mass fraction compared to the aerobic mass fraction and a nitrate load close to or exceeding the anoxic reactors denitrification potential appears to stimulate anoxic P uptake BEPR. The fact that the anoxic P uptake in this system increased steadily as the denitrification performance improved appears to link the emergence of anoxic P uptake to the processes involving nitrate in the anoxic reactor. Figure 3.24 compares the % anoxic P uptake to the nitrate/nitrite load on the anoxic reactor as well as to the NO_X denitrified in the anoxic reactor, and Figure 3.25 shows a plot of the denitrification potential of the anoxic reactor and NO_X concentration exiting the anoxic reactor versus % anoxic P uptake.

From Figure 3.24 it can be seen that the % anoxic P uptake follows the trends of both the nitrate load and NO_X denitrified. For sewage batches 10 and 11, the nitrite load was substantially higher than the nitrate load, due to the toxic sewage fed in the sewage batch before. During this period, the anoxic P uptake was low and may indicate that the denitrifying PAOs can only perform a part of the denitrification process. It seems that possibly they are only able to convert nitrate to nitrite, but unable to complete denitrification by converting nitrite to nitrogen gas. This was also found

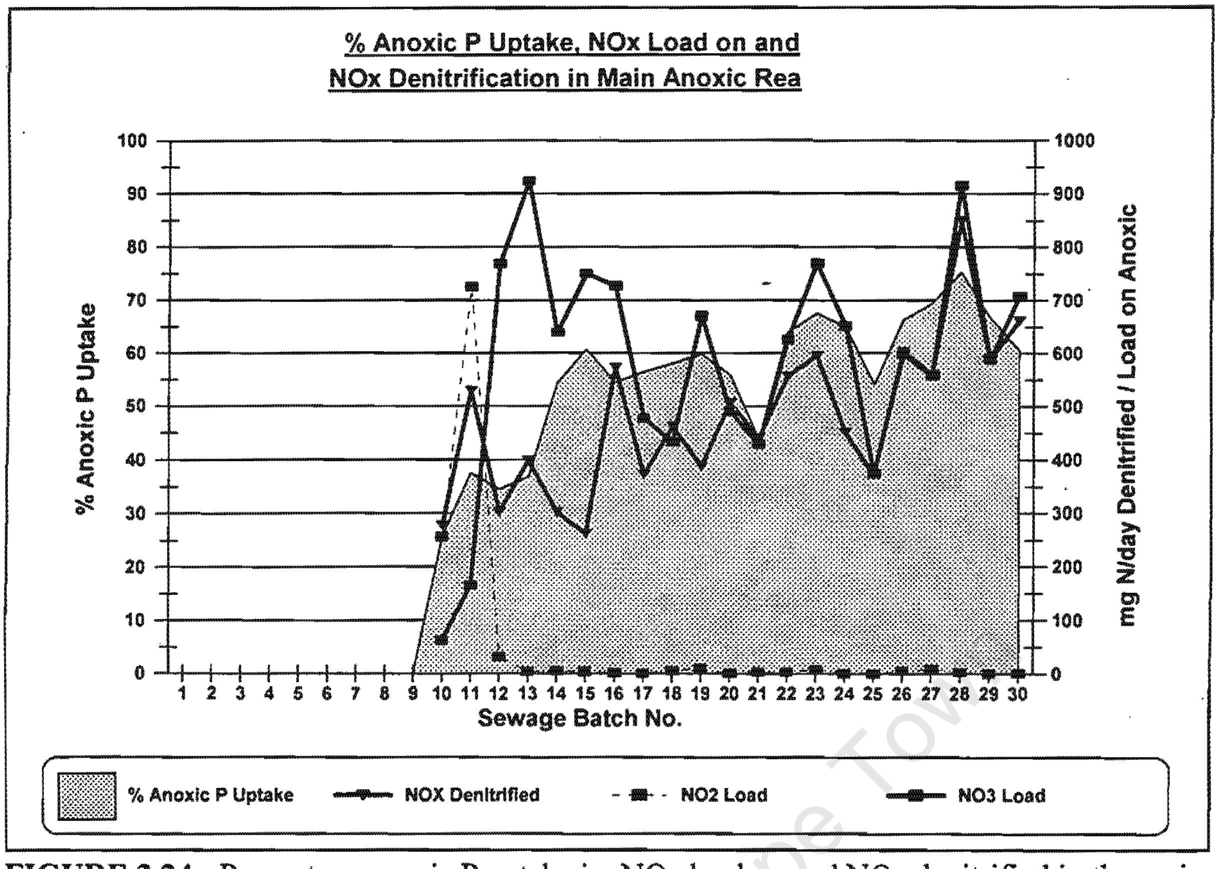

FIGURE 3.24 - Percentage anoxic P uptake in, NO_X load on and NO_X denitrified in the main anoxic reactor for sewage batches 10 to 30.

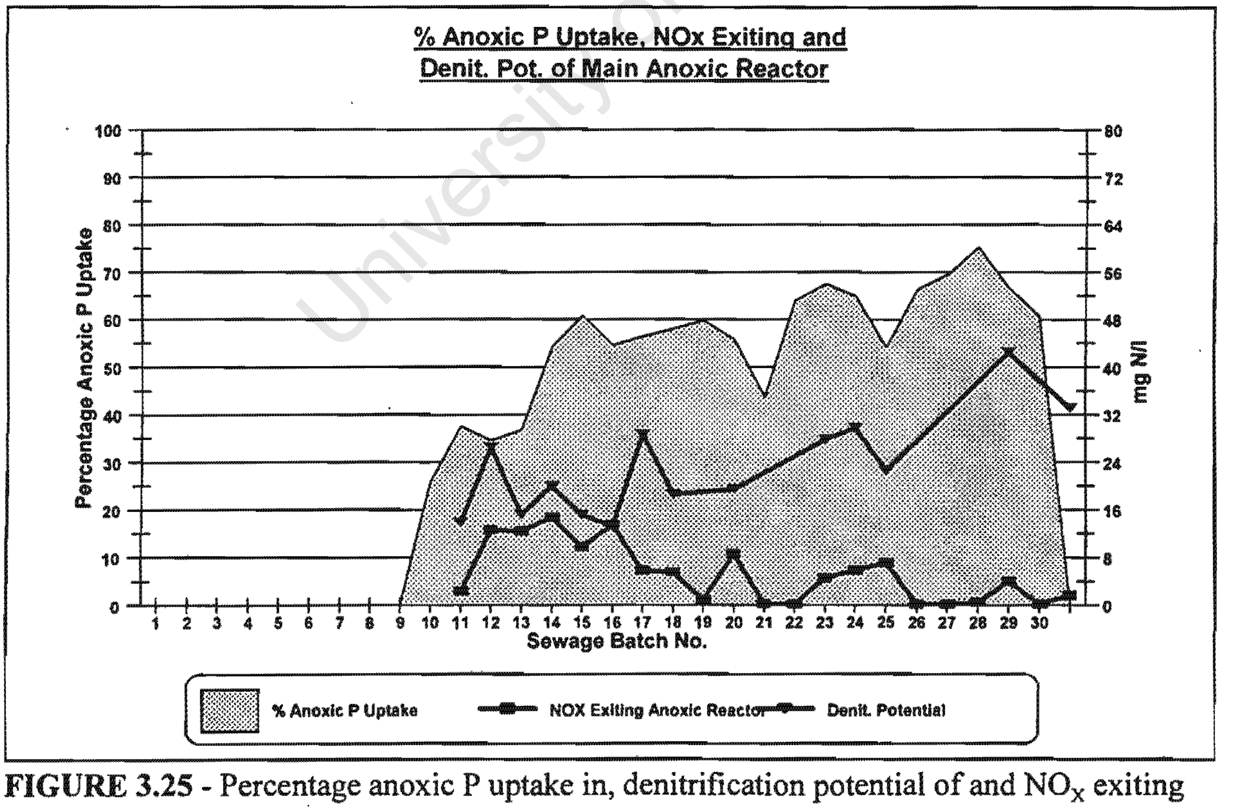

FIGURE 3.25 - Percentage anoxic P uptake in, denitrification potential of and NO_X exiting the main anoxic reactor for sewage batches 10 to 30.

by Lötter *et al.* (1986). With the nitrate producers severely inhibited after sewage batch 9, there was little nitrate to denitrify and hence the denitrifying PAOs were limited in their activity, resulting in a low percentage anoxic P uptake. However, this conclusion cannot be confirmed because the % anoxic P uptake before the toxic sewage batch is not known - it could have been low at the beginning of the investigation like Hu *et al.* (1999) found.

From both Figures 3.24 and 3.25, it can be seen that anoxic P uptake is observed to a varying degree. The % anoxic P uptake increased more significantly when the nitrate load was equal to or exceeded the denitrification potential of the anoxic reactor (calculated from nitrate in minus nitrate out (>1 mgN/l)) indicated by NO_X exiting the anoxic reactor. This indicates that when the nitrate load is low, the OHO's have preference to the available nitrate, while when there is an abundance of nitrate the PAOs have access to it also, giving rise to a concomitantly higher anoxic P uptake. Due to the fact that only a specific amount of P uptake can take place, which is linked to the P release, the P uptake will shift from anoxic to aerobic and vice versa, depending on the nitrate load on the anoxic reactor, which is ultimately dependant on the TKN/COD ratio of the influent sewage. The results indicate that anoxic P uptake increases to a maximum when the nitrate load is greater than the denitrification potential, but this will only be true until the point is reached where nitrate flows into the anaerobic reactor. At that point the P release will be reduced, and the P uptake and removal as a result also.

Also, from Figures 3.24 and 3.25, the results indicate that the PAOs that grow in an ENBNRAS system do contribute to the denitrification process. The degree to which these PAOs contribute to the denitrification process is also linked to the nitrate load on the anoxic reactor. When the load is low, as noted above, the OHO's seem to have preference for nitrate over the PAOs, leading to a lower PAO contribution to denitrification. However, when the nitrate load increases towards the denitrification potential of the reactor, the denitrification activity of the PAOs increases, leading to higher PAO contribution to denitrification and higher percentage anoxic P uptake.

An estimate of the percentage contribution that the PAOs make to the denitrification process is presented in Section 3.3.3.5 below.

3.3.3.4 Phosphorus release

P release with aerobic uptake BEPR is well understood, but there is reason to believe that the P release behaviour is different quantitatively with anoxic P uptake BEPR. P release in the ENBNRAS system therefore is different compared with P release in conventional BNRAS systems. Generally the P release by the PAOs is dependent on the concentration of RBCOD available and the proportion of that RBCOD which is utilized by the ordinary heterotrophic organisms (OHO's) in denitrifying nitrate that flows into the anaerobic reactor. In the ENBNRAS system, 57.8% of the total overall average P release occurred in the anaerobic reactor, 21.6% in the internal settler A, and 20.6% in the external nitrification system, as mentioned above.

Figure 3.26 shows the concentration of P released (mgP/l influent) versus NO_X denitrified in the anaerobic reactor (mgN/l influent) and the measured influent RBCOD concentration averages for sewage batches 10 to 30. It illustrates the effect of RBCOD and the reduction of this RBCOD by nitrate flowing into the anaerobic reactor on the P release performance of this system. It can be seen that when high concentrations of NO_X were denitrified in the anaerobic reactor (8.6 mgCOD/l of RBCOD are used to denitrify 1 $mgNO_3N/l$), the P release decreased, and when the influent RBCOD concentration was lower, the P release also decreased. If the P release decreases, the subsequent P uptake and consequently the P removal in the system also decrease.

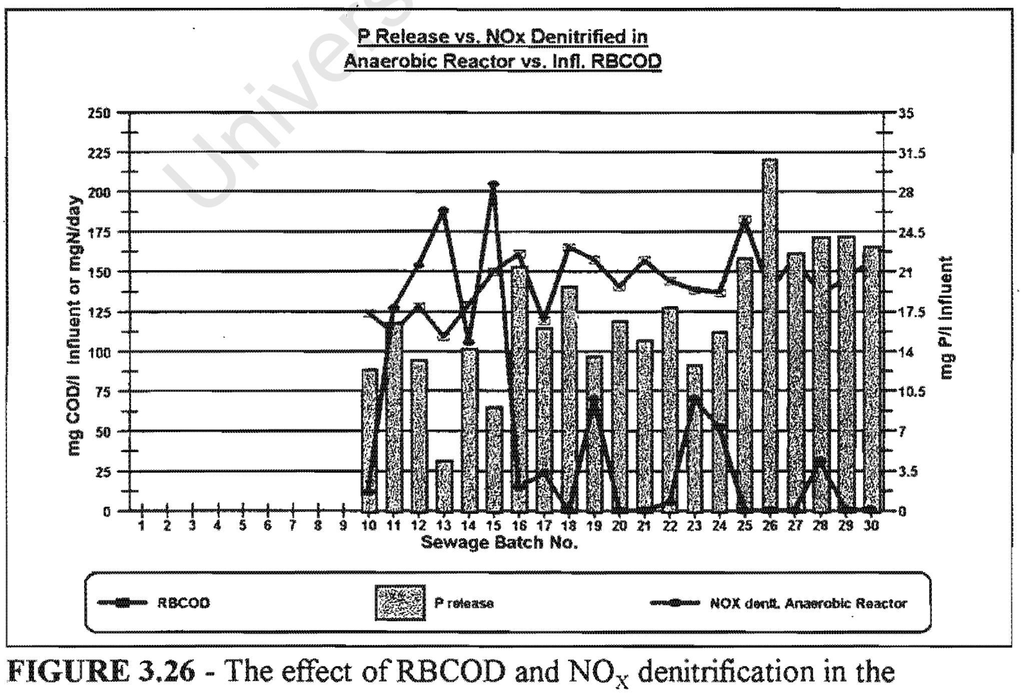

FIGURE 3.26 - The effect of RBCOD and NO_X denitrification in the anaerobic reactor on P release for sewage batches 10 to 30.

Table 3.14a below lists the theoretical P release / P uptake ratios and P release / P removal ratios calculated from the steady state aerobic uptake BEPR model of Wentzel *et al.* (1990). Table 3.14b lists the P release / P uptake and P release / P removal ratios calculated from the measurements on the ENBNRAS system of this investigation. Figure 3.27a below compares the theoretical and measured P release / P uptake ratios and Figure 3.27b compares the theoretical and measured P release / P removal ratios graphically. For the theoretical steady state model calculations, fixed $f_{S,UP}$ and $f_{XBG,P}$ (unbiodegradable particulate COD fraction and P content of PAOs) values of 0.13 and 0.38 respectively were accepted, and the influent COD concentration was adjusted for the COD removed in the external nitrification system (lost to the BNRAS system). See Appendix C for further details on the BEPR model of Wentzel *et al.* (1990).

TABLE 3.14a - Theoretical P release/P uptake and P release/P removal ratios calculated by the steady state BEPR model of Wentzel *et al.* (1990) for sewage batches 10 to 30.

Sewage Batch Number	S_{seq} mgCOD/l infl.	Theoretical $P_{released}$ mgP/l infl.	Theoretical $P_{removed}$ mgP/l infl.	Theoretical P_{uptake} mgP/l infl.	Theoretical $P_{release}/P_{uptake}$	Theoretical $P_{release}/P_{removal}$
10	93.8	46.9	16.0	62.9	0.75	2.93
11	53.6	26.8	11.1	37.9	0.71	2.41
12	48.5	24.2	11.2	35.5	0.68	2.16
13	12.2	6.1	6.5	12.6	0.49	0.94
14	63.0	31.5	11.9	43.4	0.73	2.66
15	46.7	23.4	9.9	33.2	0.70	2.36
16	117.0	58.5	18.3	76.8	0.76	3.20
17	83.3	41.7	13.9	55.5	0.75	3.00
18	125.6	62.8	19.5	82.3	0.76	3.23
19	98.2	49.1	15.9	65.0	0.76	3.09
20	110.5	55.3	17.8	73.1	0.76	3.10
21	122.8	61.4	19.2	80.6	0.76	3.20
22	108.9	54.4	17.4	71.8	0.76	3.13
23	85.2	42.6	14.7	57.3	0.74	2.90
24	104.1	52.0	17.0	69.1	0.75	3.05
25	142.1	71.1	21.6	92.7	0.77	3.28
26	104.3	52.2	16.7	68.9	0.76	3.12
27	121.2	60.6	18.7	79.4	0.76	3.24
28	96.6	48.3	16.1	64.4	0.75	3.00
29	112.2	56.1	17.9	74.0	0.76	3.14
30	124.4	62.2	19.7	81.9	0.76	3.15
Average	94.0	47.0	15.8	62.8	0.73	2.87

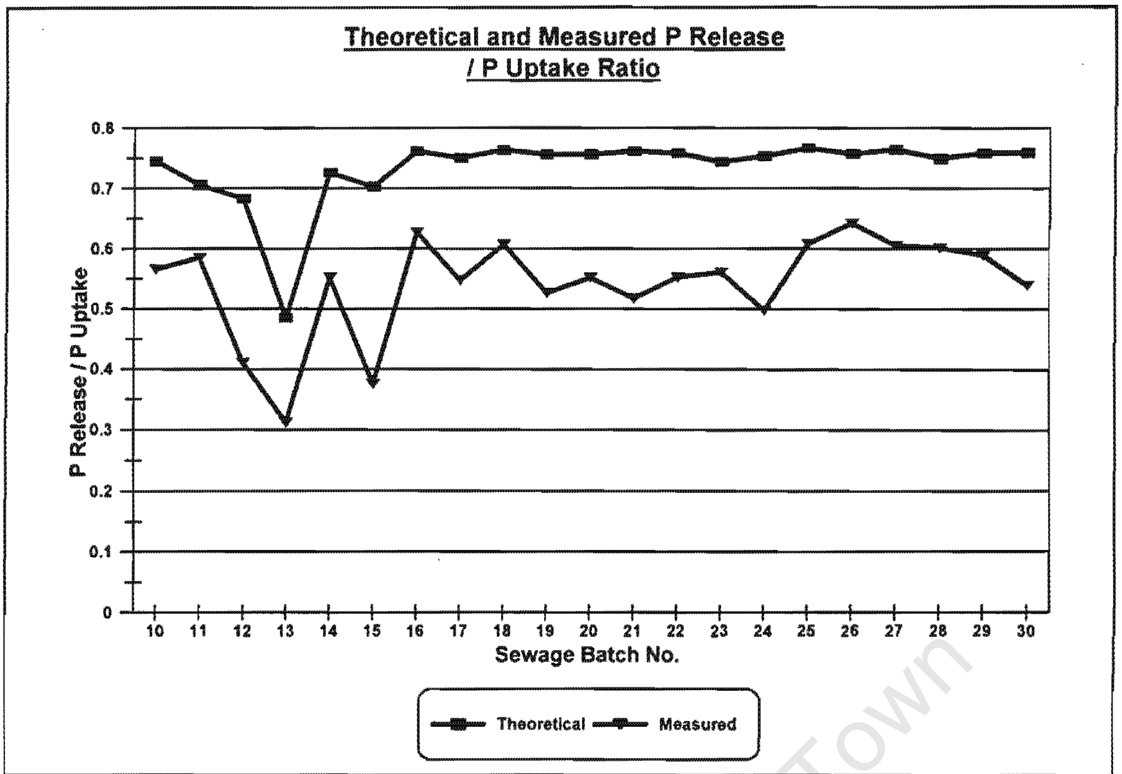

FIGURE 3.27a - Theoretical and measured P release/P uptake ratios for sewage batches 10 to 30.

TABLE 3.14b - P release/P uptake and P release/P removal ratios calculated from the measurements on the ENBNRAS system for sewage batches 10 to 30.

Sewage Batch Number	S_{seq} mgCOD/l infl.	Measured $P_{released}$* mgP/l infl.	Measured $P_{removed}$ mgP/l infl.	Measured P_{uptake} mgP/l infl.	Measured $P_{release}/P_{uptake}$	Measured $P_{release}/P_{removal}$
10	93.8	12.4	9.6	21.9	0.57	1.29
11	53.6	16.5	7.0	28.2	0.59	2.36
12	48.5	13.2	13.9	32.1	0.41	0.95
13	12.2	4.4	8.5	14.1	0.31	0.52
14	63.0	14.2	7.8	25.7	0.55	1.82
15	46.7	9.1	11.3	24.2	0.38	0.81
16	117.0	21.4	10.3	34.1	0.63	2.08
17	83.3	16.0	7.5	29.2	0.55	2.13
18	125.6	19.8	10.1	32.6	0.61	1.96
19	98.2	13.5	6.2	25.6	0.53	2.18
20	110.5	18.0	10.4	32.6	0.55	1.73
21	122.8	16.2	9.9	31.3	0.52	1.64
22	108.9	17.8	9.3	32.2	0.55	1.91
23	85.2	12.8	6.4	22.8	0.56	2.00
24	104.1	15.7	9.8	31.5	0.50	1.60
25	142.1	24.1	10.8	39.6	0.61	2.23
26	104.3	32.7	14.3	50.9	0.64	2.29
27	121.2	23.0	9.0	38.0	0.61	2.56
28	96.6	24.0	10.3	39.9	0.60	2.33
29	112.2	24.1	11.4	40.8	0.59	2.11
30	124.4	23.1	13.6	42.8	0.54	1.70
Average	94.0	17.7	9.9	31.9	0.54	1.82

*** - The measured P release does not include the P released in the external nitrification system.**

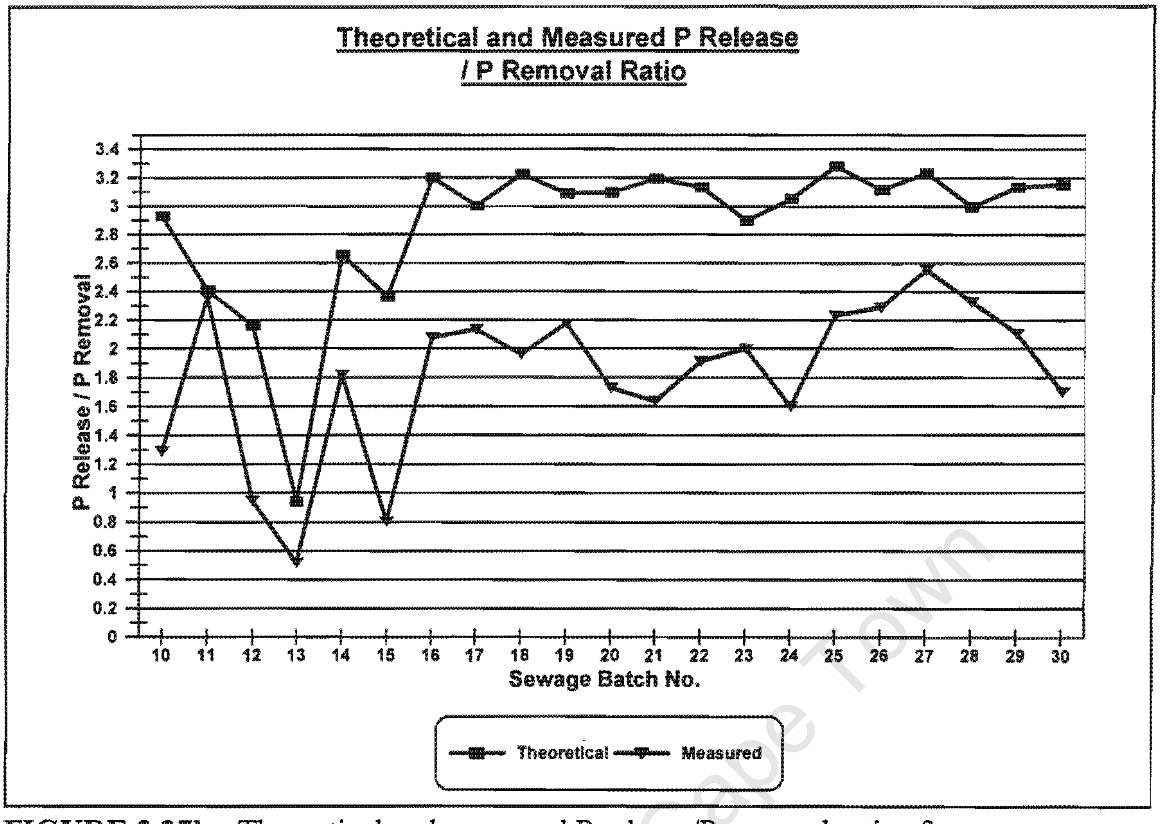

FIGURE 3.27b - Theoretical and measured P release/P removal ratios for sewage batches 10 to 30.

Table 3.14a shows that the overall average theoretical P release / P uptake and P release / P removal ratios over sewage batches 10 to 30 are 0.73 and 2.87 respectively. If it is assumed that the P release predicted by the aerobic uptake BEPR steady state model of Wentzel *et al.* (1990) also describes the P release under anoxic uptake BEPR, the P release / P uptake and P release / P removal ratios for the ENBNRAS system of this investigation should be significantly higher by virtue of the lower P removal and P uptake values shown in Table 3.14b. However, this is clearly not the case. The overall average P release / P uptake and P release / P removal ratios obtained from the measurements on the system are 0.54 and 1.82 respectively (Table 3.14b) - both significantly lower than the values predicted by the steady state model. This indicates that for anoxic uptake BEPR significantly less P is released than for aerobic uptake BEPR and also confirms that the P release behaviour under anoxic uptake BEPR differs from the P release behaviour under aerobic uptake BEPR.

The very low P release for the ENBNRAS system in this investigation was noticed during the investigation, and it was thought that some of the P was possibly trapped in the sludge pellet (that formed after the sample was centrifuged) and therefore resulted in a lower P concentration in the subsequent P analysis performed on the supernatant. This lower P concentration would have then resulted in a lower calculated P release value. To establish whether this was in fact the case, the sludge pellets were shaken up in a 0.1 molar NaCl solution, the resulting liquid filtered and the P content of the filtrate analysed separately. However, these tests did not reveal any significant P concentrations in the sludge pellets, leading to the conclusion that the low P release measured were in fact accurate values.

Figures 3.27a and 3.27b confirm that the measured P release / P uptake and P release / P removal ratios, for all 20 sewage batches shown, are consistently significantly lower than the theoretical values. On average, the measured P release / P uptake ratio is 26.0% lower than the corresponding theoretical value and the measured P release / P removal value is 36.6% lower than the corresponding theoretical value. The figures also show that both the theoretical and measured P release / P uptake and P release / P removal ratios decreased sharply after the toxic sewage batch 9 and only stabilized after sewage batch 15, when a steady state was again established. The theoretical values decreased because denitrification in the system deteriorated and resulted in nitrate discharge to the anaerobic reactor. This measured nitrate load on the anaerobic reactor is taken into account in the theoretical model and reduced the measured influent RBCOD concentration available for P removal.

3.3.3.5 Estimation of PAO contribution to denitrification

In Section 3.3.2.3 the denitrification potential of the main anoxic reactor was calculated for all sewage batches where the nitrate concentration leaving the anoxic reactor was greater than 1 mgN/l. For these sewage batches, the specific denitrification rates can be calculated. In earlier research on N and P removal systems, the PAOs were not included in the denitrification theory because most of the P uptake occurred in the aerobic zones, and there was no reason to believe that the PAOs contributed significantly to denitrification. However, with the manifestation of significant anoxic P uptake over the past five years in BNRAS systems with large anoxic mass fractions and high nitrate loads and the inherent anoxic P uptake in ENBNRAS systems indicate that the PAOs do contribute to denitrification under these circumstances. Sorm *et al.* (1996) carried out batch tests on an ENBNRAS system sludge and observed that denitrification occurred with simultaneous P uptake. They observed further that this P uptake ceased when the nitrate concentration in the mixed liquor reached zero. They concluded that the observed denitrification could include a contribution from the PAOs, and when the nitrate concentration reached zero, the internally stored PHB could no longer be utilised by the PAOs resulting in the cessation of the P uptake when the nitrate had been depleted.

With the recognition that both OHOs and PAOs contribute to denitrification in systems where significant anoxic P uptake occurs, the denitrification kinetics were extended to include the contribution of the PAOs (Ekama and Wentzel, 1999). However, the exact role of PAOs in denitrification is still uncertain. Since the ENBNRAS system of this investigation has an overall average anoxic P uptake of over 60%, the nitrate removal rates need to take account of the contribution of the PAOs. This was done with Equations 3.1 and 3.2 developed by Moodley *et al.* (1999) for the specific denitrification rate:

$$K_2^{//}OHO = \frac{D_P - f_{PAO} \times \frac{\%AnoxicPuptake \times S_{seq}}{8.6}}{X_{B,H} \times f_{XI}} \qquad \text{(Equation 3.1)}$$

$$K_2^{//}PAO = f_{PAO} \times \frac{\%AnoxicPuptake \times S_{seq}}{8.6 \times X_{B,G} \times f_{XI}} \qquad \text{(Equation 3.2)}$$

where: D_p = Measured denitrification potential (mgN/l influent) in anoxic reactor.

f_{pao} = 0 for K'_{2AVSS} which ignores the presence of PAOs in the VSS mass and all the biodegradable COD (RBCOD and SBCOD) is obtained by a single active organism group (OHOs) so that the VSS comprises only active, endogenous and inert VSS components (3) as in WRC (1984).

= 1 for K''_{2OHO} which recognises the presence of PAOs (i.e. 5 VSS components) where the COD obtained by the OHOs ($X_{B,H}$) is decreased because some of the RBCOD is obtained by the PAOs ($X_{B,G}$) and hence $X_{B,H}$ is lower than for f_{pao} = 0 alone.

S_{seq} = Calculated COD sequestered by PAOs (mgCOD/l influent) in anaerobic reactor.

$X_{B,H}$ = Calculated OHO VSS concentration (mgOHOVSS/l).

$X_{B,G}$ = Calculated PAO VSS concentration (mgPAOVSS/l).

f_{x1} = Anoxic sludge mass fraction of the anoxic reactor.

8.6 = Mg COD utilised per mgNO_3-N denitrified.

The denitrification potential is adjusted by an amount which is hypothesised to be the contribution to denitrification by the PAOs. The adjustment constitutes the product of the observed percentage of total P uptake that occurred in the main anoxic reactor and the nitrate equivalent of the RBCOD sequestered by the PAOs in the anaerobic reactor. The factor of 8.6 which converts the COD to a nitrate equivalent is obtained from $(1-f_{cv}Y_h)/2.86$, where 2.86 is the oxygen equivalent of nitrate as electron acceptor. $K_2'_{OHO}$ is the specific denitrification rate of the OHOs without any adjustment for the contribution of the PAOs, and $K_2''_{OHO}$ is the specific denitrification rate for the OHOs with the adjustment for the PAO contribution. $K_2''_{PAO}$ is therefore the resulting specific denitrification rate of the PAOs. By substituting the appropriate sewage batch average values into Equations 3.1 and 3.2, the specific denitrification rates were calculated for those sewage batches where more than 1 mgN/l nitrate flowed from the main anoxic reactor. The active mass concentrations and the COD concentration sequestered by the PAOs were taken from the VSS fractionation in Section 3.3.3.2, i.e. from Tables 3.10a and b. Since the $f_{S,UP}$ values in Section 3.3.3.2 were calculated for two scenarios, viz. (i) taking account of the COD lost to the EN system only, and (ii) taking account of the COD lost to the EN system as well as the COD unaccounted for, the same is done for the specific denitrification rates. Tables 3.15a and b show the specific OHO and PAO denitrification rates calculated for scenario (i) and (ii) respectively.

Table 3.16 shows a comparison of the specific denitrification rates of the OHOs for this system, the ENBNRAS system of Moodley *et al.* (1999) and the BNRAS systems of Clayton *et al.* (1991), Musvoto *et al.* (1992), Pilson *et al.* (1995), Mellin *et al.* (1998) and Sneyders *et al.* (1998). For this system and the system of Moodley *et al.* only the K_2' value (the specific denitrification rates without adjustment for the PAO contribution) can be compared directly with those calculated for the BNRAS systems.

FIGURE 3.15a - Calculated specific denitrification rates for sewage batches with >1 mgN/l nitrate exiting the main anoxic reactor, using values obtained from the BEPR model with COD correction for the COD lost to the EN system only.

Sewage Batch	D_P mgNO_3-N/l infl.	%Anoxic P Uptake	S_{seq} mgCOD/l	D'_P mgNO_3-N/l infl.	f_{X1}	X_{AOHO} mgAVSS/l	K_2' mgNO_3-N / mgAVSS.d	$K_2''_{OHO}$ mgNO_3-N / mgOHOAVSS.d	X_{APAO} mgAVSS/l	$K_2''_{PAO}$ mgNO_3-N / mgPAOAVSS.d
10	13.8	0.26	100.4	10.8	0.42	785.3	0.0420	0.0328	322.6	0.0224
11	26.4	0.38	56.5	23.9	0.42	820.8	0.0766	0.0694	181.7	0.0327
12	15.1	0.34	50.0	13.1	0.42	799.9	0.0450	0.0391	160.6	0.0293
13	19.9	0.37	12.6	19.4	0.42	828.8	0.0573	0.0557	40.6	0.0319
14	15.1	0.54	65.9	11.0	0.55	596.9	0.0460	0.0334	212.0	0.0355
15	13.1	0.61	49.2	9.6	0.55	647.1	0.0368	0.0269	158.3	0.0401
16	28.6	0.55	122.4	20.8	0.55	524.6	0.0992	0.0721	393.4	0.0362
17	18.6	0.56	85.1	13.0	0.55	468.7	0.0721	0.0506	273.6	0.0368
19	19.4	0.60	100.6	12.4	0.55	504.1	0.0699	0.0446	323.2	0.0395
22	27.8	0.64	111.7	19.5	0.55	511.6	0.0988	0.0692	359.0	0.0421
23	29.7	0.68	89.2	22.7	0.55	635.9	0.0850	0.0649	286.8	0.0447
24	22.5	0.65	106.6	14.5	0.55	572.5	0.0716	0.0460	342.7	0.0428
28	42.5	0.75	97.3	34.0	0.55	530.9	0.1455	0.1164	312.9	0.0493
30	33.1	0.61	128.4	24.0	0.55	635.8	0.0947	0.0686	412.8	0.0401
Avg.	23.3	0.54	84.0	17.8	0.51	633.1	0.0743	0.0564	270.0	0.0374

TABLE 3.15b - Calculated specific denitrification rates for sewage batches with >1 mgN/l nitrate exiting the main anoxic reactor, using values obtained from the BEPR model with COD correction for the COD lost to the EN system and the COD unaccounted for.

Sewage Batch	D_P mgNO_3-N/l infl.	%Anoxic P Uptake	S_{seq} mgCOD/l	D'_P mgNO_3-N/l infl.	f_{X1}	X_{AOHO} mgAVSS/l	K_2' mgNO_3-N / mgAVSS.d	$K_2''_{OHO}$ mgNO_3-N / mgOHOAVSS.d	X_{APAO} mgAVSS/l	$K_2''_{PAO}$ mgNO_3-N / mgPAOAVSS.d
10	13.8	0.26	73.9	11.6	0.42	226.2	0.1458	0.1222	237.4	0.0224
11	26.4	0.38	49.9	24.2	0.42	422.4	0.1489	0.1364	160.5	0.0327
12	15.1	0.34	43.1	13.4	0.42	376.9	0.0955	0.0848	138.4	0.0293
13	19.9	0.37	11.1	19.5	0.42	407.6	0.1165	0.1137	35.5	0.0319
14	15.1	0.54	53.1	11.8	0.55	256.8	0.1070	0.0834	170.7	0.0355
15	13.1	0.61	38.0	10.4	0.55	236.2	0.1007	0.0800	122.0	0.0401
16	28.6	0.55	104.5	21.9	0.55	284.7	0.1828	0.1401	336.0	0.0362
17	18.6	0.56	74.7	13.7	0.55	288.0	0.1173	0.0866	240.2	0.0368
19	19.4	0.60	82.4	13.6	0.55	245.5	0.1435	0.1009	264.9	0.0395
22	27.8	0.64	91.1	21.0	0.55	244.3	0.2068	0.1564	292.8	0.0421
23	29.7	0.68	71.6	24.1	0.55	263.1	0.2055	0.1664	230.3	0.0447
24	22.5	0.65	90.2	15.7	0.55	291.0	0.1408	0.0982	289.8	0.0428
28	42.5	0.75	86.9	34.9	0.55	331.7	0.2328	0.1913	279.2	0.0493
30	33.1	0.61	103.9	25.7	0.55	269.4	0.2234	0.1736	334.1	0.0401
Avg.	23.3	0.54	69.6	18.7	0.51	296.0	0.1548	0.1239	223.7	0.0374

TABLE 3.16 - Comparison of specific denitrification rates obtained for BNRAS and ENBNRAS systems (K_2' in $mgNO_X$-N/mgAVSS.d, K_2'' in $mgNO_X$-N/mgOHOVSS.d).

Researcher / System	NO_3 Denitrification Rate - K_2'			$f_{s,up}$	$f_{av,OHO}$ Active Fraction
	Mean	Maximum	Minimum		
Clayton *et al.* (1991)	0.2550	-	-	0.150	0.210
Musvoto *et al.* (1992)	0.3350	0.5170	0.1930	0.287	0.130
Pilson *et al.* (1995)	0.1810	0.3000	0.1110	0.111	0.327
Mellin *et al.* (1995)	0.2540	0.4100	0.1500	0.140	0.288
Sneyders *et al.* (1998) CTL	0.0711	0.0880	0.0500	0.062	0.435
Moodley *et al.* (1999) [Without adjustment (K_2')]	0.1379	0.2739	0.0460	0.115	0.497
Moodley *et al.* (1999) [With adjustment (K_2'')]	0.1165	0.2647	0.0347	0.115	0.497
This investigation					
K_2' {Corr. for COD loss in EN system only}	0.0743	0.1455	0.0368	0.040	0.415
K_2'' {Corr. for COD loss in EN system only}	0.0564	0.1164	0.0269	0.040	0.415
This investigation					
K_2' {Corr. for COD loss in EN system & unacc. for}	0.1548	0.2328	0.0955	0.126	0.218
K_2'' {Corr. for COD loss in EN system & unacc.for}	0.1239	0.1913	0.8000	0.126	0.218

From Table 3.15a the overall average unadjusted ($K_2'_{OHO}$) and adjusted ($K_2''_{OHO}$) specific denitrification rate of the OHOs for this system are 0.0743 $mgNO_3$-N/mgAVSS.d and 0.0564 $mgNO_3$-N/mgOHOVSS.d respectively. That of the PAOs ($K_2''_{PAO}$) is 0.0374 $mgNO_3$-N/mgPAOVSS.d based on the values from the BEPR model with COD correction for the COD lost in the EN system only. When using the values from the BEPR model with COD correction for both the COD lost to the EN system and the COD unaccounted for, the K_2' is 0.1548 $mgNO_3$-N/mgAVSS.d, the $K_2''$is 0.1239 $mgNO_3$-N/mgOHOVSS.d and the $K_2''_{PAO}$ remains unchanged at 0.0374 $mgNO_3$-N/mgPAOVSS.d. The differences in the two sets of values from Tables 3.15a and b are expected. Mellin *et al.* (1998) showed that the denitrification rates are directly proportional to the unbiodegradable particulate COD fraction ($f_{S,UP}$) of the sewage and inversely proportional to the active mass fraction. The BEPR model using the COD corrected for the COD lost to the EN system only gives a very low $f_{S,UP}$ of 0.040, but a relatively high OHO active mass fraction of 0.415, while the BEPR model using the COD corrected for both the COD lost to the EN system and the COD unaccounted for gives a higher $f_{S,UP}$ of 0.126 and a lower OHO active mass fraction of 0.218. The low $f_{S,UP}$ and high OHO active mass fraction combination results in low denitrification rates (see Table 3.15a), while the higher $f_{S,UP}$ and lower OHO active mass fraction combination result in much higher denitrification rates (see Table 3.15b).

The $K_2'_{OHO}$ of 0.0743 $mgNO_3$-N/mgAVSS.d obtained with the COD correction for COD lost to the EN system only is substantially lower than those obtained by Musvoto *et al.*, Pilson *et al.*, Mellin *et al.* and Moodley *et al.*, but close to that of Sneyders *et al.* (see Table 3.16). The $K_2'_{OHO}$ of 0.1548 $mgNO_3$-N/mgOHOVSS.d obtained with the COD correction for both the COD lost to the EN system and the COD unaccounted for is higher than those obtained by Sneyders *et al.* and Moodley *et al.*, but still somewhat lower than the $K_2'_{OHO}$ obtained by Musvoto *et al.*, Pilson *et al.* and Mellin *et al.* The higher $K_2'_{OHO}$ value of 0.1548 $mgNO_3$-N/mgAVSS.d is however much closer to those measured by the other researchers. However, it should be noted that only in this investigation was the influent SBCOD reduced to take account of the COD lost in the COD mass balance; Clayton *et al.*, Musvoto *et al.*, Pilson *et al.*, Mellin *et al.*, Sneyders *et al.*, Hu *et al.* and Moodley *et al.* did not do so, so their denitrification rates are not directly comparable to the scenario (ii) rates calculated in this investigation. The BEPR model appears to give VSS values (i.e. more realistic $f_{S,UP}$ values) closer to those actually measured in the system when the influent SBCOD is adjusted for the COD lost to the EN system *and* for the COD unaccounted for, resulting in more consistent values for the OHO and PAO active mass fractions and hence for the specific denitrification rates.

The specific denitrification rates of the PAOs (see Tables 3.15a and b) is 0.0374 $mgNO_3$-N/mgPAOVSS.d for both the COD correction scenarios. If the COD is adjusted for the COD lost to the EN system only, the PAO denitrification rate is 40% of that of the OHOs, but if the COD is adjusted for the COD lost to the EN system and for the unaccounted fraction, the PAO denitrification rate is 23% of that of the OHOs.

3.3.4 Sludge Settleability

3.3.4.1 Filament identification

Throughout the 17 month laboratory investigation (February 1999 to June 2000), microscopic filament analyses were performed on samples of the main aerobic reactor of the laboratory scale ENBNRAS system at approximately one monthly intervals. This was done to ascertain whether the laboratory scale system shows similar filamentous organism growths to the full scale BNRAS systems in South Africa. The six most frequently dominant filaments in South African BNRAS systems are type 0092, type 0675, type 0041, *M.parvicella*, type 0914 and type 1851. These are followed by type 0803, *Nocardia, H.hydrossis, N.limicola*, type 1863 and *Thiothrix* which are also present, but rarely cause bulking (Blackbeard *et al.* 1986, 1988). The combination of the six most frequently dominant filaments listed above conform to a low F/M filament bulking sludge that is so prevalent in South African BNRAS systems with long sludge ages.

The complete monthly filament identifications for this system can be found in Appendix D. Tables 3.17a and b below show a summary of the filament identifications. Table 3.17a lists the filaments that were identified and gives their rank as a percentage. For example, *M.parvicella* was identified in 94% of the 17 identifications (i.e. *M.parvicella* was identified in 16 of the 17 identifications) and in the 16 identifications that it was present, it was ranked number 1 in 59% (10) and number 2 in 35% (6) of these 16 identifications. Table 3.17b lists the abundance level of the filaments, also as a percentage. In the case of *M.parvicella*, of the 16 identifications it was present, in 19% of them (3) their abundance level was classified as 'few', in 38% (6) as 'some', in 12% (2) as 'common' and in 25% (4) as 'very common'.

TABLE 3.17a - The occurrence of filamentous organisms in the laboratory scale ENBNRAS system.

Filamentous Organism	Rank 1	Rank 2	Rank 3	Rank 4	Overall occurrence
	Percentage of occurrence in 17 monthly filament identifications				
M. parvicella	59	35	-	-	94
Type 1851	41	35	-	-	76
Type 0092	-	18	6	-	24
H.hydrossis	-	6	6	-	12
Type 1701	-	-	6	-	6
Thiothrix sp.	-	-	6	-	6
Type 0041	-	-	6	-	6
Norcardia sp.	-	-	-	6	6

TABLE 3.17b - The abundance level of filamentous organisms occurring in the laboratory scale ENBNRAS system.

Filamentous Organism	When identified, percentage recorded abundance level				
	Few	Some	Common	Very Common	Abundant
M. parvicella	19	38	12	25	6
Type 1851	8	54	38	0	0
Type 0092	0	75	25	0	0
H.hydrossis	100	0	0	0	0
Type 1701	100	0	0	0	0
Thiothrix sp.	100	0	0	0	0
Type 0041	100	0	0	0	0
Norcardia sp.	100	0	0	0	0

Tables 3.17a and b show that *M.parvicella* occurred most often (in 16 out of 17 identifications), followed by type 1851 (13 out of 17 identifications). The other filamentous organisms occurred more seldom, with type 0092 occurring in 4, *H.hydrossis* in 2 and type 1701, *Thiothrix sp.*, type 0041 and *Norcardia sp.* each in only 1 of the 17 identifications. When occurring, on average, *M.parvicella's* abundance level was between 'some' and 'common', type 1851 and type 0092's abundance level was 'some' and the remaining filaments, when occurring, were only 'few'. In effect *M.parvicella* was the most commonly occurring and abundant filament, followed by type 1851. Type 0092 did not occur as often, but when it did occur, it did so relatively abundantly. The remaining filamentous organisms were only found occasionally, and at very low abundance levels.

The three most common filaments in the laboratory scale ENBNRAS system are amongst the six usually found in low F/M bulking sludges of full scale BNR plants in South Africa, and the remaining filamentous organisms identified are also all found in these sludges, with the exception of type 1701. Jenkins *et al.* (1984) associated type 1701 with low dissolved oxygen (DO), but since type 1701 occurred only once at a low abundance, it cannot be seen as an indication of low DO in the aerobic reactor. The most important observation is the fact that the filamentous organisms identified in the ENBNRAS system are indicative of a low F/M bulking sludge, and hence not dissimilar from those sludges found in full scale BNRAS system in South Africa.

In the investigation on the ENBNRAS system of Moodley *et al.* (1999), *M.parvicella* (81% occurrence), type 1851 (44% occurrence) and type 021N (25% occurrence) were the most common filamentous organisms. Others present included type 0092, *H.hydrossis*, type 1701 and *S.natans*. With the exception of type 021N and *S.natans,* which were never identified in the system of this investigation, the filament identifications show the existence of similar filamentous organisms that occur most frequently in the two ENBNRAS systems.

3.3.4.2 Dilute sludge volume index (DSVI)

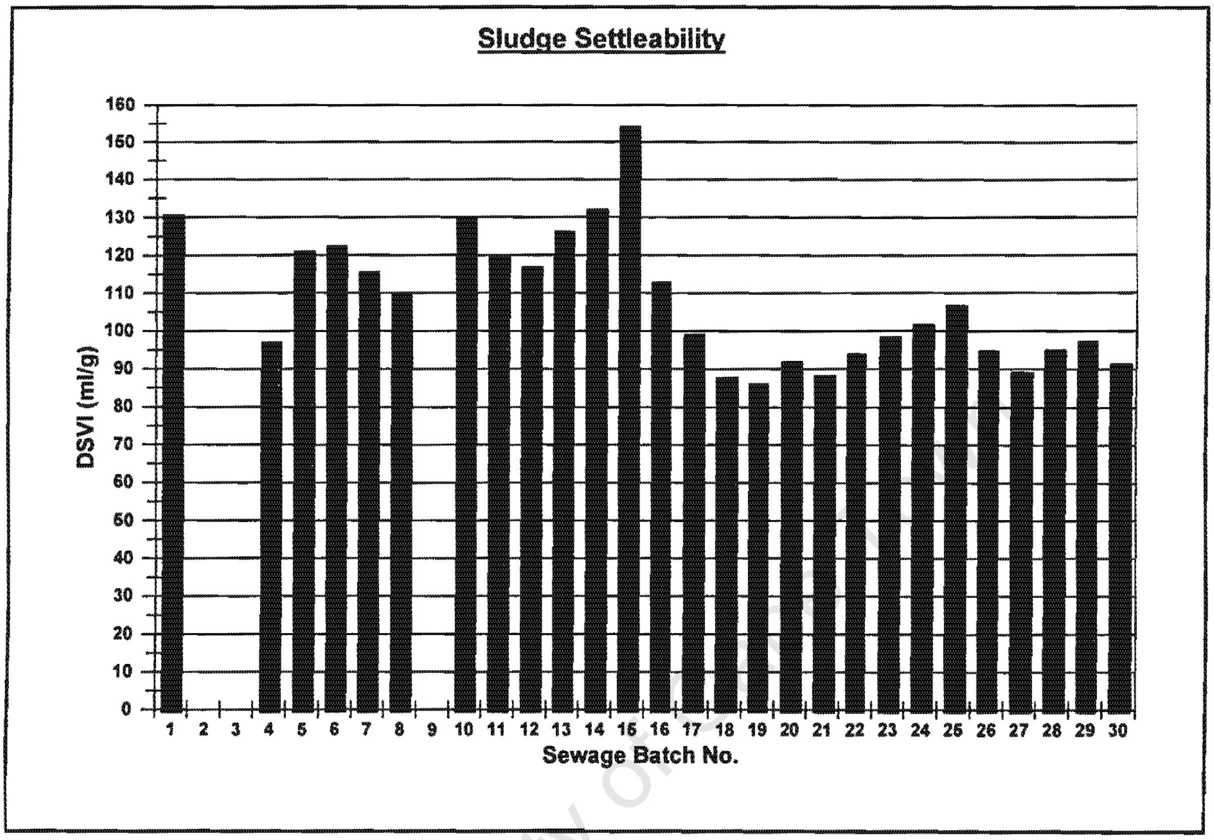

FIGURE 3.28 - Dilute sludge volume index for sewage batches 1 to 30.

The overall average dilute sludge volume index (DSVI) for this system was 108 ml/g. From Figure 3.28 it can be seen that the highest DSVI value over the 30 sewage batches was 154 ml/g (sewage batch 15) and the lowest DSVI was 86 ml/g (sewage batch 19). At the beginning of the investigation the DSVI was quite high (for a ENBNRAS system) at 130 ml/g after which it improved slightly to about 110 ml/g by sewage batch 8. After the toxic sewage batch 9 the DSVI increased to a value of about 155 ml/g by sewage batch 15. By sewage batch 15 the system had recovered from the toxic sewage batch, which appears to be also reflected in the DSVI. After sewage batch 15 the DSVI decreased to between 90 and 100 ml/g for the remainder of the investigation. The average DSVI for sewage batches 17 to 30 is about 90 ml/g.

The average of 90 ml/g shows that the sludge was a good settling sludge, considering that full scale BNRAS systems produce sludges that settle between 150 and 250 ml/g. Hu *et al.* (1999)

and Moodley *et al.* (1999) reported overall average DSVI's of 70 ml/g and 94 ml/g respectively for their laboratory scale ENBNRAS systems. The overall average DSVI of 108 ml/g for this system is slightly higher than that of Moodley *et al.*, but negligibly so. The DSVI of Hu *et al.* was about 38 ml/g lower than that of this investigation, but the DSVI of just over 100 ml/g is no cause for concern and is certainly not a bulking sludge. The results from Hu *et al.*, Moodley *et al.* and this system indicate that for an ENBNRAS system the DSVI can be expected to be in the range of 70 to 110 ml/g, which is a very good result compared with 'conventional' BNRAS systems.

Casey *et al.* (1994) proposed a hypothesis for the proliferation of anoxic-aerobic (AA) filamentous organisms in nitrification-denitrification BNRAS systems (see Section 2.3.4 for details). In short, the hypothesis states that for systems that exhibit an anoxic-aerobic sequence of reactors, the floc-forming organisms that facilitate the denitrification process in the anoxic zone are inhibited to a certain extent from utilising oxygen in the subsequent aerobic reactor by nitric oxide - an intra-cellular enzymatically bound byproduct of the denitrification process from nitrate to nitrogen gas. This inhibition places the floc-forming organisms at a disadvantage in the aerobic reactor, because the filamentous organisms, which do not reduce nitrate further than nitrite (and hence do not suffer from this inhibition of utilising the oxygen) are able to utilise a greater portion of the available substrate. With the floc-forming organisms inhibited and the filamentous organisms at an advantage, the filamentous organisms increase their relative mass and this leads to filamentous organism proliferation and results in bulking sludges. The extent of the inhibition on the floc-forming organisms is related to the concentration of nitrate exiting the anoxic reactor, i.e. if complete denitrification occurs in the anoxic reactor there will be no significant inhibition, and if high concentrations of nitrate (>1 mgN/l) flow from the anoxic reactor the inhibition will be significant.

Figure 3.29 shows the NO_X concentration exiting the anoxic reactor of this system together with the DSVI for sewage batches 1 to 30. From Figure 3.29 it can be seen that higher NO_X concentrations flowing from the anoxic reactor do have a small effect on the DSVI. In sewage batches 1 to 15 an average of 9.4 mgN/l nitrate flowed from the anoxic reactor, while in sewage batches 16 to 30 an average of only 3.0 mgN/l nitrate flowed from the anoxic reactor. The average DSVI for the former period was 123 mg/l and for the latter period 96 ml/g. The difference in these average DSVI's is not large, and while 9.4 mgN/l nitrate flowed from the anoxic reactor in the first 15 sewage batches the average DSVI of 123 ml/g is far from the bulking sludges of 250ml/g or higher experienced in some 'conventional' full scale BNRAS systems. It can be further seen from Figure 3.29 that the peaks in the NO_X concentrations (e.g. sewage batches 19, 24 and 28) do result in a more dampened peak in the corresponding DSVI values, but with a lag of one batch. In other words, the NO_X peak of sewage batch 24 for example, caused a peak in the DSVI value of sewage batch 25, and so on.

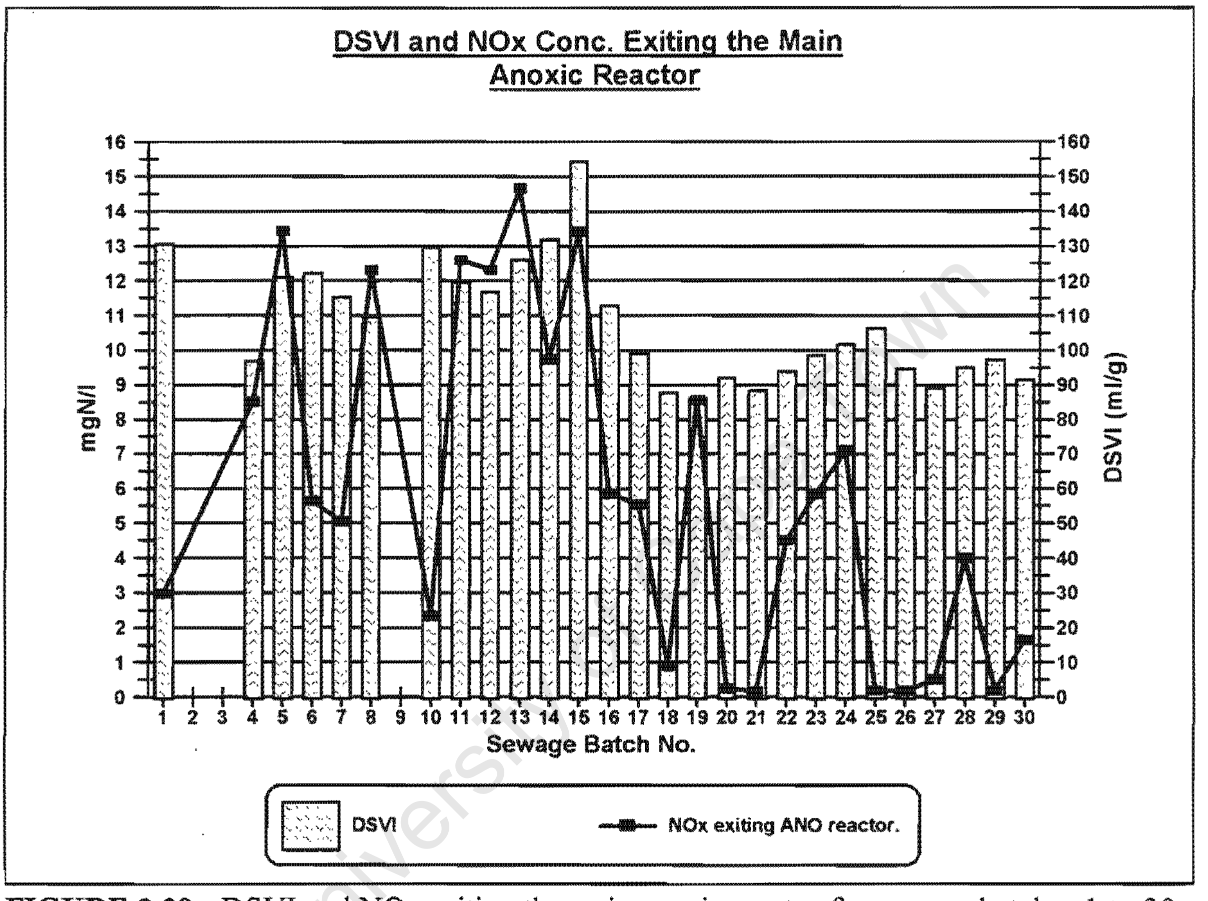

FIGURE 3.29 - DSVI and NO_X exiting the main anoxic reactor for sewage batches 1 to 30.

Casey *et al.* (1994) further reported after studying the sludge settleability and aerobic mass fraction data for seven full scale BNRAS systems (see Section 2.3.4 for details), that BNRAS systems with a low aerobic mass fraction of between 0 and 0.30 and systems with a very high aerobic mass fraction of between 0.75 and 1 settle very well (see Figure 2.3). In contrast, systems that have an aerobic mass fraction of between 0.30 and 0.75 produce sludges that are prone to AA filament proliferation and therefore do not settle well, with the worst settling sludges occurring at an aerobic mass fraction between 0.35 and 0.65. In terms of this observation, the system of this investigation would be expected to produce a sludge with good settleability because of its low aerobic mass fraction. Configuration 1 had an aerobic mass fraction of 0.33 and all subsequent configurations had an aerobic mass fraction of 0.20. The aerobic mass fraction was lowered from 0.33 to 0.20 at the end of sewage batch 13 and a marked improvement in the DSVI can be seen from sewage batch 16 onwards (see Figure 3.28). With the combination of the lowering of the aerobic mass fraction for sewage batch 14 and the recovery of the system from the bad sewage batch 9 from batch 15 onwards, it is difficult to say whether the improvement in DSVI occurred because of the lowering of the aerobic mass fraction or because of the system recovering from a bad batch of sewage. In all likelihood it was a combination of the two factors that caused the DSVI to improve and settle at the improved DSVI of between 90 and 100 ml/g for the remainder of the investigation.

3.4 SYSTEM PERFORMANCE AT SLUDGE AGES SHORTER THAN 10 DAYS

The evaluation of the laboratory scale ENBNRAS system performance at sludge ages lower than 10 days was not part of the initial scope of this investigation. However, towards the end of the practical laboratory investigation it was decided to increase the influent sewage flow from 20 l/d to 30 l/d in order to observe the system response to this 50% increase in load. Shortly after the influent flow had been increased to 30 l/d, the system began to fail hydraulically in that the internal settling tanks A and B (see Figure 3.1) showed signs of imminent failure. Instead of allowing the system to fail completely as a result of the hydraulic failure, it was decided to reduce the influent flow to 25 l/d and that instead of implementing a gradual increase in feed, a gradual reduction in sludge age should rather be implemented. At the beginning of sewage batch 31 (18/04/2000) the influent was increased from 20 to 30 l/d. Two days later, on the 20/04/2000, it was reduced to 25 l/d and the sludge age was decreased from 10 to 8 days (Configuration 4, see Table 3.1). The system was run at the 8 day sludge age for sewage batches 31, 32 and 33 (49 days, 6 sludge ages) after which the sludge age was reduced further to 5 days (Configuration 5, see Table 3.1) at the beginning of sewage batch 34 (08/06/2000).The system was run at a 5 day sludge age for a further 13 days to the 21/06/2000 (3 sludge ages). For the 5 day sludge age 4 l/d were wasted. The 4 l/d could no longer be taken from the 4 l aerobic reactor in one batch, so a small peristaltic pump was installed and calibrated to waste 4 l of mixed liquor from the aerobic reactor over a 24 hour period.

Given the comparatively short time that the system was run at these low sludge ages it would be of little practical value to give as detailed an evaluation for the 8 and 5 day sludge age system configurations as was done in Section 3.3.3 for the 10 day sludge age configuration. For this reason only a brief comparison of the main nutrient removal performances (COD, N and P) will be given in this section below. The sewage batch averages for of all measured parameters for sewage batches 31 to 34 (Configurations 4 and 5) are given in Tables 3.18a, b and c.

TABLE 3.18a - Sewage batch averages of measured COD and TKN parameters for sewage batches 31 to 34.

Sewage Batch	mgCOD/l							mgN/l								
	COD							TKN				FSA				TKN/COD Ratio
	Influent	Floc Filt. Infl.	Int. Set. A	Int. Set. B	Aerobic M.L	Unfilt. Effl.	Filt. Effl.	Influent	Aerobic M.L	Unfilt. Effl.	Filt. Effl.	Influent	Int. Set. A	Int. Set. B	Unfilt. Effl.	Influent
31	731.6	158.3	153.6	77.6	2392.4	61.5	38.1	64.3	150.4	4.6	3.7	50.0	23.4	2.9	3.1	0.088
32	779.8	191.3	145.6	92.2	2564.8	62.7	41.0	79.9	149.5	5.0	4.1	64.0	28.7	3.4	3.5	0.103
33																
34	709.2	186.2	161.5	91.4	1735.2	83.9	31.6	87.5	123.0	6.9	4.1	71.8	33.7	2.7	2.8	0.120
Overall	740.2	178.6	153.5	87.0	2230.6	69.4	38.2	77.3	141.0	5.5	4.0	62.0	28.6	3.0	3.1	0.104
*	UF	FF	UF	UF	UF	UF	F	UF	UF	UF	F	UF	UF	UF	UF	UF

TABLE 3.18b - Sewage batch averages of measured suspended solids, OUR, DSVI and pH for sewage batches 31 to 34.

Sewage Batch	mg SS/l								mgO/l/h	ml/g		
	TSS	VSS	ISS[1]	TSS	VSS	ISS[1]	COD/VSS Ratio[2]	TKN/VSS Ratio[2]	OUR	DSVI	pH	
	PreANO	PreANO	PreANO	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Anaerobic	Aerobic
31	3782.4	3094.6	687.8	1957.4	1625.6	331.8	1.45	0.09	19.9	92.6	7.50	7.97
32	4013.2	3263.8	749.4	2109.4	1738.4	371.0	1.45	0.09	25.5	86.9	7.43	7.85
33												
34	2759.7	2253.7	506.0	1409.7	1176.6	233.1	1.44	0.11	17.7	92.9	7.89	7.85
Overall	3518.4	2870.7	647.7	1825.5	1513.5	312.0	1.45	0.10	21.1	90.8	7.61	7.89

1 ISS calculated from TSS - VSS.
2 Calculated from unfiltered aerobic reactor COD and TKN concentrations divided by the VSS.

TABLE 3.18c - Sewage batch averages for measured nitrate, nitrite and P concentrations for sewage batches 31 to 34 (all concentrations measured on glassfibre filtered samples).

Sewage Batch	mgN/l													
	Nitrite							Nitrate						
	PreANO	Anaerobic	Int. SET A	Int. SET B	Anoxic	Aerobic	Filt. Effl.	PreANO	Anaerobic	Int. SET A	Int. SET B	Anoxic	Aerobic	Filt. Effl.
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	17.6	0.1	0.1	0.6
32	0.0	0.1	0.1	0.1	0.7	0.3	0.2	0.1	0.1	0.2	23.7	1.2	3.3	2.9
33														
34	0.6	0.0	0.0	0.0	0.3	1.2	0.6	10.9	0.2	0.2	34.9	15.0	15.9	17.0
Overall	0.3	0.0	0.0	0.1	0.4	0.5	0.3	3.7	0.1	0.2	25.4	5.4	6.4	6.8

Sewage Batch	mgP/l								
	Phosphates								
	Influent	PreANO	Anaerobic	Int. SET A	Int. SET B	Anoxic	Aerobic	Unfilt. Effl.	Filt. Effl.
31	25.1	13.2	28.1	30.2	33.0	21.5	10.8	10.4	9.6
32	26.3	14.1	32.0	33.8	36.5	24.1	14.5	14.1	13.8
33									
34	26.0	15.3	23.8	25.5	28.0	22.2	18.3	18.9	17.4
Overall	25.8	14.2	28.0	29.8	32.5	22.6	14.5	14.5	13.6

3.4.1 Carbonaceous Material Removal

Table 3.19 shows the COD mass balances (including their components) and percentage COD removals for sewage batches 31 to 34. Table 3.20 gives a comparison of the most important COD parameters for the 10, 8 and 5 day sludge age configurations.

TABLE 3.19 - COD mass balances for sewage batches 31 to 34.

Average of Batch	Influent COD mgCOD/d	MOC mgO/d	Denitrification Recovery mgCOD/d	COD used Ext. Nit. mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	COD out mgCOD/d	% Recovery	% COD Removal
31	18290	1795	2174	3322	5981	1383	14655	80.4	92.4
32	19496	2054	2962	2284	6412	1411	15123	78.0	92.8
33									
Config.4	*18893*	*1924*	*2568*	*2803*	*6197*	*1397*	*14889*	*79.2*	*92.6*
34	17729	1336	3224	2990	6941	1762	16253	91.8	90.1
Config.5	*17729*	*1336*	*3224*	*2990*	*6941*	*1762*	*16253*	*91.8*	*90.1*

TABLE 3.20 - Comparison of average COD parameters for 10, 8 and 5 day sludge age system configurations.

	ENBNRAS System Configurations		
	1,2 and 3	4	5
	10 Day Sludge Age	8 Day Sludge Age	5 Day Sludge Age
% COD Reduction	94%	93%	90%
OUR	19.9 mgO/l.h	22.7 mgO/l.h	17.7 mgO/l.h
COD Balance	79.8%	79.2%	91.8%
% COD to Oxygen	13.8	10.2	7.5
% COD to Denitrification	12.7	13.6	18.2
% COD to EN System	19.7	14.8	16.8
% COD in Waste	26.7	32.8	39.2
% COD in Effluent	6.2	7.4	9.9
% COD Unaccounted	20.8	21.2	8.3

The overall average COD mass balance for the 10, 8 and 5 day sludge age system configurations are 79.8%, 79.2% and 91.8% respectively (see Table 3.20). The overall COD mass balances for the 10 and 8 day sludge age configurations are virtually the same, but that for the 5 day sludge age configuration is substantially higher. This is probably because the VSS concentration had not yet reached a steady state value for the 5 day sludge age. The overall average COD mass balance components for the various sludge age configurations do not show any unexpected changes, except that for the 5 day sludge age configuration the % COD in the wasted VSS is probably higher than would be at steady state. The variations in %COD to oxygen and % COD to denitrification can be attributed to variations in the influent sewage characteristics rather than to the different sludge ages. A higher influent COD will bring about a slight increase in the oxygen utilisation rate (OUR) and a higher influent TKN/COD ratio will cause a shift from the COD passed to oxygen to the COD utilised for denitrification.This can be clearly noted for the 10 and 5 day sludge age configurations. For the 10 day sludge age configuration which received an average of 735.7 mgCOD/l influent with a TKN/COD ratio of 0.106, 13.8% of the COD was passed to oxygen and 12.7% of the COD was utilised for denitrification. For the 5 day sludge age configuration the influent COD was 709.2 mgCOD/l with a TKN/COD ratio of 0.120. The combination of the lower COD in the influent and the substantially higher TKN/COD ratio resulted in 10.2% of the COD being passed to oxygen and 18.2% of the COD being utilised for denitrification. There is no reason for the percentage COD 'lost' to the EN system to change with a lowering of the sludge age of the system, and the results for the three sludge ages are similar. The minor variations can be attributed to the different number of sewage batches fed rather than to the change in sludge age. The percentage COD in the waste is the only parameter that is expected to change with the sludge age. A shorter sludge age results in more mixed liquor being wasted and hence the percentage COD in the waste will be proportionally more. This can clearly be seen from Table 3.20: The 10 day sludge age configuration has an overall average of 26.7% of the influent COD in the waste flow, while the 8 day sludge age configuration has 32.8% and the 5 day sludge age configuration 39.2% (which is probably somewhat high as noted above) - an increase for each respective reduction in sludge age. The percentage COD in the unfiltered effluent shows a similar trend to the COD in the waste sludge, but is not as a result of the lower sludge age. The influent flow for the 8 and 5 day sludge age configurations was increased from 20 to 25 l/d and this put greater strain on the final settler causing a greater fraction of the dispersed suspended solids to spill over with the effluent. The filtered effluent COD concentration remained essentially unchanged at 36.2 mgCOD/l.

The overall COD reduction for the three sludge age configurations are all within 4% of each other (94% for the 10 day sludge age configuration, 93% for the 8 day and 90% for the 5 day sludge age configuration), indicating that the COD removal of the ENBNRAS system in not affected to any great extent by a reduction in sludge age.

3.4.2 Nitrogenous Material Removal

Table 3.21a lists the results for the nitrite and nitrate mass balances over each reactor and settler for sewage batches 31 to 34. As before, a negative value indicates nitrification and a positive value denitrification. Table 3.21b gives the results for the total N mass balances and all of its components for sewage batches 31 to 34. Table 3.22 lists the denitrification potentials for the pre- and main anoxic reactors for those batches where the nitrate concentration exiting the respective anoxic reactor was >1 mgN/l.

TABLE 3.21a - Nitrite and nitrate mass balances across each reactor and settling tank for sewage batches 31 to 34.

Average of Batch	NITRITE						
	Δ PreANO mgN/d	Δ Anaerobic mgN/d	Δ Int. Set. A mgN/d	Δ Int. Set. B+Nit mgN/d	Δ Anoxic mgN/d	Δ Aerobic mgN/d	Δ Fin. SET mgN/d
31	-0.0	-0.2	-0.1	-1.1	0.1	0.8	0.3
32	2.9	-1.4	-2.0	-1.6	-30.2	23.8	4.4
33							
Config. 4	*1.4*	*-0.8*	*-1.0*	*-1.3*	*-15.0*	*12.3*	*2.3*
34	0.9	17.3	0.4	1.0	-15.7	-43.1	18.4
Config. 5	*0.9*	*17.3*	*0.4*	*1.0*	*-15.7*	*-43.1*	*18.4*
Average of Batch	**NITRATE**						
	Δ PreANO mgN/d	Δ Anaerobic mgN/d	Δ Int. Set. A mgN/d	Δ Int. Set. B+Nit mgN/d	Δ Anoxic mgN/d	Δ Aerobic mgN/d	Δ Fin. SET mgN/d
31	14.1	-1.7	-3.4	-738.3	740.5	-26.5	0.7
32	71.8	-2.0	-4.7	-964.2	913.2	-104.2	15.7
33							
Config. 4	*43.0*	*-1.9*	*-4.0*	*-851.2*	*826.9*	*-65.4*	*8.2*
34	150.8	263.3	1.8	-1415.1	676.1	-48.0	-46.5
Config. 5	*150.8*	*263.3*	*1.8*	*-1415.1*	*676.1*	*-48.0*	*-46.5*

TABLE 3.21b - N mass balance with all components for sewage batches 31 to 34.

Average of Batch	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery	% N Removal
31	1.5	759.2	377.4	117.1	131.0	1386.3	1608.3	86.2	92.7
32	34.4	1015.2	382.6	181.2	73.0	1686.3	1997.5	84.4	90.9
33									
Config. 4	*18.0*	*887.2*	*380.0*	*149.1*	*102.0*	*1536.3*	*1802.9*	*85.3*	*91.8*
34	39.4	1103.8	560.4	518.0	-152.7	2068.8	2188.0	94.5	76.3
Config. 5	*39.4*	*1103.8*	*560.4*	*518.0*	*-152.7*	*2068.8*	*2188.0*	*94.5*	*76.3

TABLE 3.22 - Denitrification potential of the pre- and main anoxic reactors for sewage batches where the outflow NO_X concentration exceeds 1 mgN/l, for sewage batches 31 to 34.

	Main Anoxic		Pre Anoxic		Total Anoxic Mass Fraction of System
Batch	NO(x) Denitrified mgN/d	Denit. Potential mgN/l infl.	NO(x) Denitrified mgN/d	Denit. Potential mgN/l infl.	
31	740.06		14.1		0.55
32	913.2	45.7	74.7		0.55
33					
34	676.1	33.8	151.7	7.6	0.55

Table 3.23 shows a comparison of the main N parameters for the 10, 8 and 5 day sludge age configurations.

TABLE 3.23 - Comparison of average N parameters for 10, 8 and 5 day sludge age configurations.

	ENBNRAS System Configurations		
	3	4	5
	10 Day Sludge Age	8 Day Sludge Age	5 Day Sludge Age
N Balance	88.1 %	85.3 %	94.5 %
% NO_2 Denit.	2.1	1.0	1.8
% NO_3 Denit.	40.7	49.2	50.4
% N Wasted	19.4	21.1	25.6
% N in Effluent	9.2	8.3	23.7
% N Loss to EN System	16.7	5.7	0.0
% N Unaccounted	11.9	14.8	5.4
Nitrification Occurring Externally	91.1 %	92.9%	94.5 %
TKN in Final Effluent (Unfiltered)	4.8 mgN/l	4.8 mgN/l	6.9 mgN/l
FSA in Final Effluent	3.6 mgN/l	3.3 mgN/l	2.8 mgN/l
NOx in Final Effluent	3.2 mgN/l	1.90 mgN/l	17.8 mgN/l
Total N in Final Effluent	8.0 mgN/l	6.7 mgN/l	24.7 mgN/l
Denit. Pot. Pre-Anoxic Reac.	3.7 mgN/l influent	-	7.6 mgN/l influent
Denit. Pot. Main Anoxic Reac.	31.1 mgN/l influent	45.7 mgN/l influent	33.8 mgN/l influent
TKN/COD Ratio of Influent	0.107	0.096	0.12
Total N Reduction	90.8 %	91.8%	76.3%
TKN Reduction	94.0%	93.3%	92.1%

The overall average N mass balance for the 10 (Configuration 3), 8 and 5 day sludge age configurations are 88.1%, 85.3% and 94.5% respectively. As for the overall COD mass balances, the 10 and 8 day sludge age configurations have a similar overall average N mass balance, while that for the 5 day sludge age configuration is higher because the VSS concentration had not yet reached a steady state value. As was the case with the COD mass balance components, the variations in the N mass balance components are a result of factors that are independent of the lowering of the sludge age, with the exception of the N in the waste sludge. The overall average nitrite denitrification of 2.1% for the 10 day sludge age configuration is higher than the 1.0% and 1.8% for the 8 and 5 day sludge ages respectively. The percentage of the influent N denitrified via nitrate denitrification was 40.7% for the 10 day sludge age configuration and 49.2 and 50.4% for the 8 and 5 day sludge age configurations respectively. The percentage N leaving the system in the waste sludge increased with decreasing sludge age as expected, from 19.4% for the 10 day sludge age configuration to 21.1 for the 8 day, and 25.6% for the 5 day sludge age configuration. This is the result of a greater volume of mixed liquor wasted, especially for the 5 day configuration because the VSS concentration had not yet reached a steady state value. The percentage N in the final effluent of 9.2%, 8.3% and 23.7% for the 10, 8 and 5 day sludge age configurations respectively are difficult to compare as they are a function of the nitrate concentration in the effluent which depends on the TKN/COD ratio of the influent as well as the nitrification and denitrification performance of the system.

One of the main motives in implementing the ENBNRAS system configuration was to uncouple the nitrification process from the main system and hence making nitrification independent of sludge age. Table 3.23 clearly shows the success of this system configuration - nitrification remained completely unaffected by the lowering of the sludge age. For the 8 and 5 day sludge age configurations 92.9 and 94.5% of the system nitrification occurred externally. This is even higher than the 90.8% for the 10 day sludge age configuration. From the final effluent FSA concentrations given in Table 3.23, it can be seen that full nitrification occurred throughout the 8 and 5 day sludge age configurations with only the residual FSA (from the internal settler A underflow) appearing in the effluent.

The overall average denitrification potential of the main anoxic reactor was 31.1 mgN/l influent, 45.7 mgN/l influent and 33.8 mgN/l influent for the 10, 8 and 5 day sludge age configurations respectively. The overall average TKN removal was 94.0%, 93.9% and 92.1% for the 10, 8 and 5 day sludge age configurations respectively. The TKN removals are very similar and all above 90%, which is a very good result. The total N (TN) removal (TKN and NO_X) was 90.8%, 91.8% and 76.3% for the 10, 8 and 5 day sludge age configurations respectively. The TN removals show more variation, but this is not due to the decrease in sludge age. The criteria that govern the TN removal are the system nitrification and denitrification as well as the TKN/COD ratio of the influent. For an influent with, for example, a high TKN/COD ratio, full nitrification and poor denitrification, the concentration of nitrate in the effluent will be high, leading to a lower overall TN removal. This is reflected in the results for the 10, 8 and 5 day sludge age configurations. The overall average TKN/COD ratio of the influent for the 10 day sludge age configuration was 0.107 and the denitrification potential of the main anoxic reactor 31.1 mgN/l influent, resulting in an overall average TN removal of 90.8%. The overall average influent TKN/COD ratio for the 8 day sludge age configuration was 0.096, and the denitrification potential of the main anoxic reactor was 45.7 mgN/l influent, resulting in an overall average TN removal of 91.8% - showing that the lower influent TKN/COD ratio combined with the higher denitrification potential of the main anoxic reactor resulted in a better TN removal performance for the 8 day sludge age configuration. The influent TKN/COD ratio of the 5 day sludge age configuration was a high 0.120 and the denitrification potential of the main anoxic reactor was 33.8 mgN/l influent (higher than for the 10 day, but significantly lower than for the 8 day sludge age configuration), which resulted in a overall average TN removal of only 76.3%, which is lower than that of both the 10 and 8 day sludge age configurations.

Accepting the variations occurring in the N removal parameters because of varying influent sewage characteristics as well as varying denitrification performance, the lowering of the sludge age did not have any marked effect on either nitrification, denitrification or TKN and TN removal. The results achieved for the 10 (Configuration 3), 8 and 5 day sludge age configurations are very similar and this shows that the ENBNRAS system configuration is able to attain high N removals at sludge ages up to as low as 5 days.

3.4.3 Biological Excess Phosphorus Removal (BEPR)

Table 3.24 shows the results of the P mass balances over each of the reactors and settling tanks for sewage batches 31 to 34. A negative result indicates P release while a positive result indicates P uptake. Table 3.25 show a comparison for the main P parameters for the 10, 8 and 5 day sludge age configurations.

FIGURE 3.24 - Average P release (-ve) or P uptake (+ve) for each reactor/settler and total P removal for sewage batches 31 to 34.

Batch	Δ Pre-ANO mgP/l infl.	Δ Anaerobic mgP/l infl.	Δ Int.SET A mgP/l infl.	Δ Int. SET B+Nit. mgP/l infl.	Δ Anoxic mgP/l infl.	Δ Aerobic mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Total P Removal	% Recovery
31	-3.6	-17.9	-4.2	-4.6	22.1	21.3	2.5	15.5	15.5	100
32	-0.3	-23.7	-3.5	-4.4	23.7	19.5	1.1	12.5	12.5	100
33										
Config. 4	*-1.9*	*-20.8*	*-3.9*	*-4.5*	*22.9*	*20.4*	*1.8*	*14.0*	*14.0*	100
34	2.11	-6.25	-3.42	-4.11	10.76	7.82	1.71	8.63	8.63	100
Config. 5	2.11	-6.25	-3.42	-4.11	10.76	7.82	1.71	8.63	8.63	100

TABLE 3.25 - Comparison of average P parameters for the 10, 8 and 5 day sludge age configurations.

	ENBNRAS System Configurations		
	3	4	5
	10 Day Sludge Age	8 Day Sludge Age	5 Day Sludge Age
NO_x Flowing into Anaerobic Reac.	0.95 mgN/l	0 mgN/l	10.9 mgN/l
P Release (excl. rel. in EN sys.)	20.8 mgP/l influent	26.6 mgP/l influent	9.67 mgP/l influent
P Uptake	36.4 mgP/l influent	45.1 mgP/l influent	22.4 mgP/l influent
Anoxic P Uptake	63.3%	47.1%	57.9%
P Removal	10.5 mgP/l influent	14.0 mgP/l influent	8.6 mgP/l influent

A reduction in sludge age increases P removal per mass of organic load (Wentzel *et al.*, 1990), provided that it is not reduced below a lower limit (~ 3 days) to prevent the PAOs from being 'washed' out of the system completely. It would therefore be expected that the 8 and 5 day sludge age configurations should show improved P removal compared to the 10 day sludge age system configuration. From Table 3.25 it can be seen that the overall average P removal was 10.5 mgP/l influent, 14.0 mgP/l influent and 8.6 mgP/l influent for the 10, 8 and 5 day sludge age configurations respectively. The low P removal for the 5 day sludge age configuration occurred because the influent TKN/COD ratio was very high and this led to a high concentration of nitrate (10.9 mg/l, see Table 3.25) being recycled to the anaerobic reactor and limiting the P release, resulting in a low overall P removal performance of 8.6 mgP/l influent. This is however not linked to the short sludge age, but rather to the main anoxic reactor being overloaded by the high nitrate load that resulted from the high TKN/COD ratio of the influent. The 8 day sludge age configuration showed the highest P removal (14.0 mgP/l influent), but there was no nitrate leaking into the anaerobic reactor during this configuration and this contributed to the higher overall P removal. The 10 day sludge age configuration achieved an overall average P removal of 10.5 mgP/l influent with an average of 0.95 mgN/l flowing into the anaerobic reactor from the pre-anoxic reactor. Even with zero nitrate flowing into the anaerobic reactor the 10 day sludge age configuration would not have achieved an average P removal of 14.0 mgP/l influent, showing that a reduction in sludge age does improve the P removal performance. Had no nitrate flowed into the anaerobic reactor during the 5 day sludge age configuration, it would probably have achieved higher P removal than the 8 day sludge age configuration did.

For the 10 day sludge age configuration, an overall average of 63.3% of the P uptake occurred in the anoxic reactor. For the 8 and 5 day sludge age configurations, the percentage anoxic P uptake was 47.1 and 57.9% respectively. The average NO_X load on the main anoxic reactor was 18.6 mgN/l, 20.7 mgN/l and 34.9 mgN/l for the 10, 8 and 5 day sludge age configurations respectively. The higher NO_X load on the anoxic reactor for the 5 day sludge age configuration led to the 10.8% higher anoxic P uptake compared to that of the 8 day sludge age configuration. The 8 day sludge age configuration had a 2.4 mgN/l higher NO_X load on the anoxic reactor than the 10 day sludge age configuration, but 14.8% lower anoxic P uptake. This is most likely because the 8 day sludge age configuration result is an average of only two sewage batches, while the result from the 10 day sludge age configuration is the average of 10 sewage batches. Had the 8 day sludge age configuration been run for 10 sewage batches, the result would have been closer to that of the 10 day sludge age configuration.

When the ENBNRAS system is operated at lower sludge ages, an improvement in the overall P removal can be expected. Considerable anoxic P uptake continues to occur at the lower sludge ages, and the percentage anoxic P uptake continues to shift with the NO_X load on the main anoxic reactor.

3.4.4 Sludge Settleability

The overall average DSVI was 95.6 ml/g, 89.8 ml/g and 92.9 ml/g for the 10 (Configuration 3), 8 and 5 day sludge age configurations respectively. This shows that the decrease in sludge age had no effect on the DSVI performance of the ENBNRAS system. It cannot be said that the lowering of the sludge age produced a better settling sludge, because the values of the 8 and 5 day sludge age configurations are close to those obtained for the 10 day sludge age configuration (Configuration 3). Even with a nitrate concentration of 15 mgN/l flowing from the main anoxic reactor(Table 3.18c) for the 5 day sludge age configuration the DSVI deteriorated only very slightly and did not rise above 100 ml/g as it did for the 10 day sludge age system configuration when similarly high nitrate concentrations flowed from the anoxic reactor during the period that the system was recovering from the bad sewage batch 9.

3.5 COMPARISON OF ENBNRAS SYSTEM WITH A BNRAS (UCT) SYSTEM

A laboratory scale BNRAS system (UCT configuration) with similar design and operating parameters to the ENBNRAS system of this investigation was run in parallel with the laboratory scale ENBNRAS system. Figure 3.30 shows the system layout of the laboratory scale UCT system and Table 3.26 lists the design and operating parameters for both the ENBNRAS and UCT systems. In order to compare the performance of the two systems, they were fed the same influent sewage for 18 sewage batches (sewage batches 13 to 30) - from the 7 August 1999 (day 167) to the 17 April 2000 (day 421). 40 l of influent were prepared in the same container, thoroughly stirred, and 20 l of this prepared sewage was fed to each of the systems respectively. While the ENBNRAS system was operated and analysed by the writer, the UCT system was operated, tested and reported on by Vermande *et al.* (2000). All the analytical results of the UCT system given in this section are taken from the Vermande *et al.* (2000) report and are listed in Appendix E.

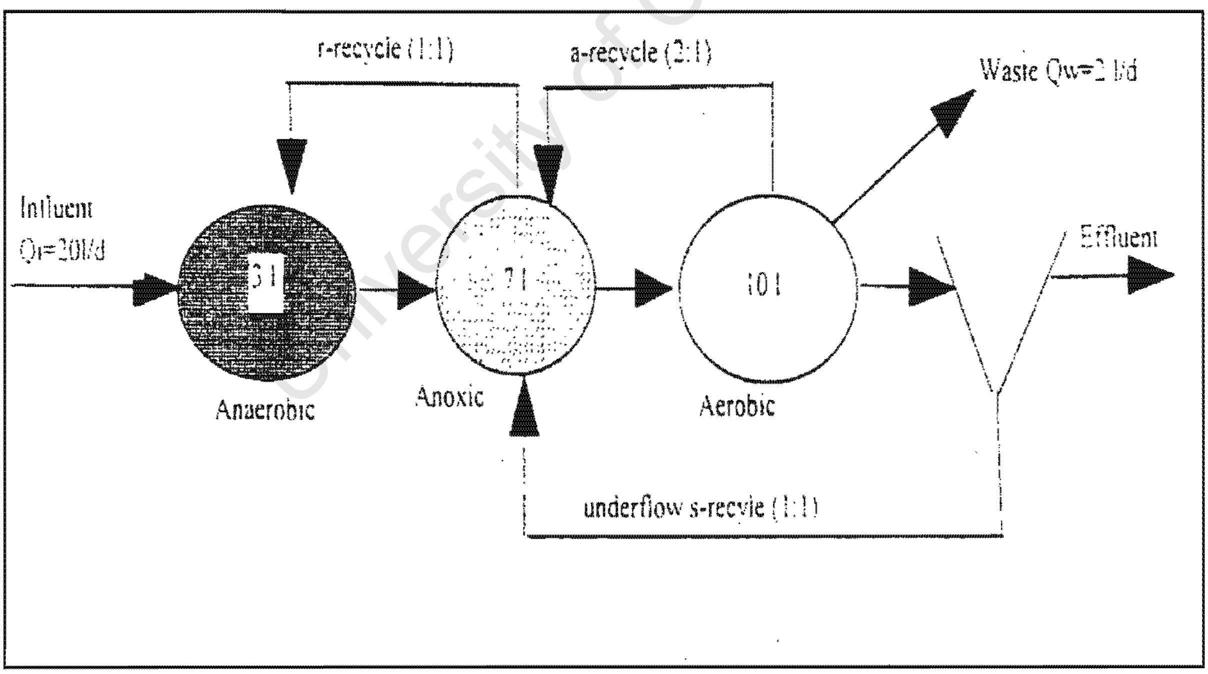

FIGURE 3.30 - Schematic layout of the laboratory scale UCT system run in parallel with the laboratory scale ENBNRAS system.

TABLE 3.26 - ENBNRAS and UCT system design and operating parameters.

Parameter	UCT System	ENBNRAS System
Influent Flow (l/d)	20	20
Sludge Age (d)	10	10
Temperature (°C)	20	20
D.O. Main Aerobic Reactor (mgO/l)	2 to 5	2 to 5
Total System Volume (l)	20	20
Pre-Anoxic Reactor (l)	-	2*
Anaerobic Reactor (l)	3**	5
Main Anoxic Reactor (l)	7	6.5 (for sewage batch 13) 9 (for sewage batches 14 to 30)
Main Aerobic Reactor (l)	10	6.5 (for sewage batch 13) 4 (for sewage batches 14 to 30)
Aerobic Mass Fraction	0.5	0.33 (for sewage batch 13) 0.2 (for sewage batches 14 to 30)
Unaerated Mass Fraction	0.5	0.67 (for sewage batch 13) 0.8 (for sewage batches 14 to 30)
Anoxic Mass Fraction	0.35	0.42 (for sewage batch 13) 0.55 (for sewage batches 14 to 30)
Anaerobic Mass Fraction	0.15	0.25
a-recycle (w.r.t infl. flow)	1:1	2:1 (for sewage batches 13 to 20) 0:1 (for sewage batches 21 to 30)
s- recycle (w.r.t infl. flow)	1:1	1:1
r - recycle (w.r.t infl. flow)	1:1	-

* Actual volume 1l, with sludge at double concentration.
** Actual volume 6l, with sludge diluted to half the normal concentration.

Tables 3.27a, b and c list the sewage batch averages for all measured parameters for sewage batches 13 to 30 for the UCT system. The sewage batch numbers correspond to the sewage batch numbers used for the ENBNRAS system to facilitate a direct comparison of the two systems. Where the overall averages of the two systems are compared in this section, the overall averages refer to the average of the sewage batch averages for sewage batches 13 to 30. This also applies to the ENBNRAS system results - in this section the overall averages refer to the average of the sewage batch averages for sewage batches 13 to 30 calculated from Tables 3.4a, b and c. Therefore the overall averages may differ from those mentioned in Sections 3.1 to 3.3, where the overall averages include sewage batches 1 to 30.

TABLE 3.27a - Sewage Batch averages of measured COD and TKN parameters for the UCT system for sewage batches 13 to 30 (UF = unfiltered; F = 0.45μm membrane filtered).

Sewage Batch	mgCOD/l				mgN/l						
	COD				TKN				FSA		TKN/COD Ratio
	Influent	Aerobic M.L	Unfilt. Effl.	Filt. Effl.	Influent	Aerobic M.L	Unfilt. Effl.	Filt. Effl.	Influent	Unfilt. Effl.	Influent
13	790.9	2651.4	67.4	43.2	82.1	150.4	2.6	2.1	61.3	1.9	0.104
14	685.6	2732.2	57.5	37.6	71.3	101.7	2.7	1.3	52.7	1.4	0.104
15	723.1	2170.1	55.3	43.7	89.2	160.5	5.4	1.9	69.8	2.0	0.123
16	732.3	2595.5	61.5	47.8	83.0	168.0	3.2	1.6	62.3	1.1	0.113
17	675.5	2492.9	43.8	31.1	63.8	171.3	3.2	1.8	47.8	1.1	0.094
18	784.3	2505.5	49.7	38.6	64.7	161.2	3.0	1.6	52.0	0.6	0.083
19	788.7	2084.2	46.5	39.7	84.5	156.8	3.1	2.3	68.2	0.6	0.107
20	784.9	2320.7	54.9	43.0	69.1	159.4	3.1	2.8	50.3	1.1	0.088
21	715.5	2538.7	55.2	37.7	63.2	183.5	4.1	3.3	49.9	2.5	0.088
22	718.6	2411.8	55.3	43.2	77.2	163.3	5.1	4.7	60.9	2.9	0.107
23	760.1	2386.3	56.9	39.7	79.9	150.4	5.2	3.8	61.4	2.7	0.105
24	721.1	2224.2	42.6	35.5	86.7	145.6	4.9	3.1	68.3	2.4	0.120
25	694.6	2510.5	42.0	35.8	58.2	160.9	3.7	2.8	46.7	2.1	0.084
26	699.1	2294.6	46.4	38.5	84.5	150.9	4.5	3.1	70.6	1.9	0.121
27	687.9	2775.3	53.9	38.6	82.2	169.3	4.6	3.3	72.6	2.1	0.119
28	716.2	2850.3	52.9	33.0	88.1	188.1	5.1	3.1	71.4	2.6	0.123
29	748.9	2784.8	56.5	41.2	67.3	180.0	4.5	3.2	57.2	2.2	0.090
30	799.1	2761.4	56.3	42.7	68.3	172.8	3.5	2.1	53.9	1.4	0.085
Overall	**734.8**	**2505.0**	**53.0**	**39.5**	**75.7**	**160.8**	**4.0**	**2.6**	**59.9**	**1.8**	**0.103**
*	UF	UF	UF	F	UF	UF	UF	F	UF	UF	UF

TABLE 3.27b - Sewage batch averages of measured suspended solids, OUR, DSVI and pH for the UCT system for sewage batches 13 to 30.

Sewage Batch					mgO/l/h	ml/g		
	TSS	VSS	COD/VSS Ratio [1]	TKN/VSS Ratio [1]	OUR	DSVI	pH	
			Aerobic	Aerobic	Aerobic	Aerobic	Anaerobic	Aerobic
13	2226.4	1838.4	1.42	0.082	32.4	115.2	-	-
14	2102.7	1704.3	1.58	0.096	39.0	73.4	-	-
15	2002.7	1624.0	1.31	0.097	29.3	94.3	-	-
16	2066.3	1699.0	1.50	0.098	36.7	114.3	-	-
17	2128.3	1698.0	1.45	0.101	31.0	112.0	-	-
18	1946.3	1567.7	1.57	0.102	31.1	119.8	-	-
19	1777.8	1444.5	1.42	0.109	32.3	121.1	-	-
20	1988.3	1609.3	1.42	0.100	29.3	112.8	-	-
21	2207.3	1780.7	1.40	0.103	31.8	112.1	-	-
22	2137.5	1696.5	1.40	0.096	35.5	145.1	-	7.77
23	1931.3	1580.4	1.48	0.095	34.5	186.8	-	7.81
24	1972.7	1642.4	1.33	0.089	35.3	197.1	7.68	7.87
25	2208.4	1813.6	1.36	0.089	30.3	183.1	7.56	7.91
26	2056.3	1672.5	1.35	0.090	33.3	201.0	7.61	7.82
27	2480.0	1923.1	1.42	0.088	27.6	154.9	7.53	7.83
28	2499.2	2006.7	1.40	0.094	28.0	157.2	7.51	7.80
29	2409.0	1878.0	1.46	0.096	26.5	144.1	7.35	7.91
30	2492.8	1900.3	1.43	0.091	28.0	141.6	6.89	7.14
Overall	2146.3	1726.6	1.43	0.095	31.8	138.1	7.4	7.76

[1] Calculated from unfiltered aerobic reactor COD and TKN concentrations divided by the VSS.

TABLE 3.27c - Sewage batch averages for measured nitrate, nitrite and P concentrations for the UCT system for sewage batches 13 to 30.

Sewage Batch									mgP/l					
	Nitrite				Nitrate				Phosphates					
	Anaerobic	Anoxic	Aerobic	Filt. Effl.	Anaerobic	Anoxic	Aerobic	Filt. Effl.	Influent	Anaerobic	Anoxic	Aerobic	Unfilt. Effl.	Filt. Effl.
13	0.1	0.5	1.8	1.5	0.5	1.2	13.1	13.4	26.2	31.1	21.2	14.7	-	14.3
14	0.0	0.1	0.6	0.4	0.3	2.4	15.5	13.4	26.2	31.3	17.4	8.3	-	7.3
15	0.0	0.2	0.7	0.4	0.3	5.3	20.0	22.2	30.8	30.2	19.4	14.6	-	13.9
16	0.0	0.1	1.1	1.0	0.1	1.2	13.4	13.6	25.0	33.4	22.6	13.6	-	14.0
17	0.1	0.2	0.3	0.2	0.1	0.3	8.3	8.6	25.4	34.5	21.3	12.6	-	13.0
18	0.0	0.1	0.2	0.2	0.1	0.3	8.4	7.8	26.9	35.9	23.5	14.1	-	14.7
19	0.0	0.3	0.5	0.2	0.1	0.9	11.2	12.2	21.0	30.9	21.3	13.0	-	12.6
20	0.1	0.1	0.2	0.1	0.1	0.3	8.3	8.6	25.8	32.9	21.8	13.5	-	13.5
21	0.1	0.1	0.1	0.1	0.2	0.3	7.0	7.9	25.2	33.6	22.2	14.9	15.1	15.1
22	0.1	0.9	0.5	0.2	0.2	1.0	10.5	11.5	24.6	28.7	19.5	14.6	15.1	14.9
23	0.1	0.8	0.7	0.5	0.2	1.7	12.5	13.4	23.0	25.8	18.9	15.8	15.5	15.7
24	0.1	0.5	0.4	0.6	0.2	1.0	12.5	13.3	25.2	29.2	19.0	15.0	14.9	14.6
25	0.0	0.1	0.2	0.1	0.1	0.2	8.0	8.2	28.7	33.3	23.3	18.0	18.0	17.7
26	0.0	0.5	0.8	0.4	0.1	2.4	15.1	17.2	29.1	35.0	23.8	17.5	16.8	16.6
27	0.0	0.4	0.3	0.2	0.2	2.9	15.7	16.9	25.6	35.8	19.5	11.9	11.8	11.1
28	0.0	0.4	0.4	0.3	0.2	1.6	15.0	16.1	25.3	38.6	22.9	13.1	12.6	12.0
29	0.1	0.1	0.3	0.1	0.1	0.1	8.1	8.3	24.9	41.9	20.0	8.4	9.0	8.2
30	0.0	0.1	0.1	0.2	0.1	0.6	9.8	10.0	26.8	41.7	21.3	9.5	8.8	8.5
Overall	**0.1**	**0.3**	**0.5**	**0.4**	**0.2**	**1.3**	**11.8**	**12.4**	**25.9**	**33.5**	**21.0**	**13.5**	**13.8**	**13.2**

It should further be noted that because the chemical tests were performed by two different researchers, the influent sewage characteristics show some minor differences, even though the respective feeds originated from the same feed mixing container. This is as a result of the independent analyses and associated analytical variations, but these do not impact much on the comparison, because the overall averages of the influent sewage characteristics over the 18 sewage batches are almost identical. Furthermore, both independent analyses arrived at the same overall average COD/VSS ratio of 1.43 and TKN/VSS ratio of 0.1 over the 18 sewage batches.

3.5.1 Carbonaceous Material Removal

Figure 3.31 shows the overall COD mass balances achieved for sewage batches 13 to 30 for the UCT and the ENBNRAS systems.

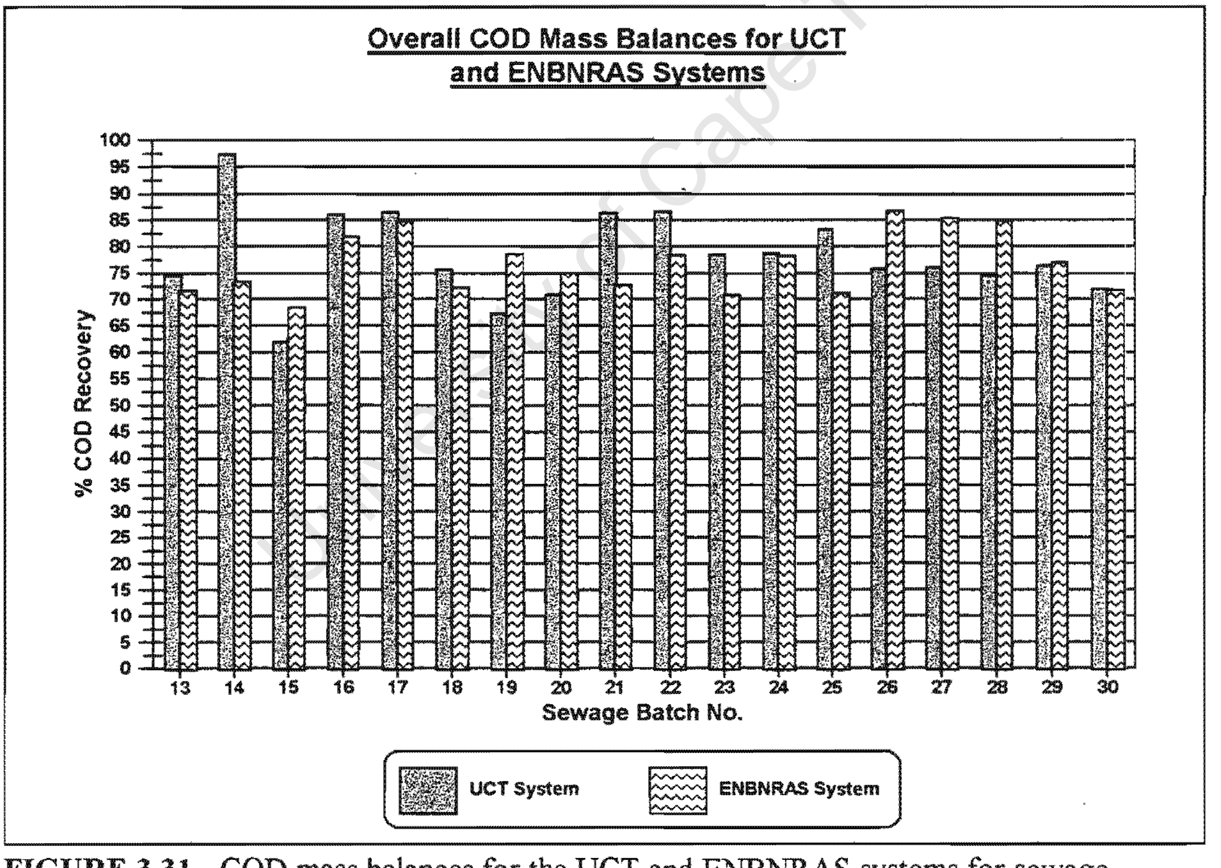

FIGURE 3.31 - COD mass balances for the UCT and ENBNRAS systems for sewage batches 13 to 30.

The overall average COD mass balance achieved for the UCT system is 78.3% and that for the ENBNRAS system is 76.8%. These values are within 2 percent, indicating that while the overall average COD mass balance for the UCT system is 1.5% higher than the overall average COD mass balance achieved for the ENBNRAS system, both are equally low. This indicates that the same as yet unidentified biological process which is thought to consume a fraction of the influent COD without being taken account of in the usual analytical procedures also occurred in the UCT system, and it confirms that the low COD balances are not characteristics of the ENBNRAS system alone, but rather a characteristic of BNRAS systems in general. From Figure 3.31 it can be seen that the COD mass balances achieved for each sewage batch are similar. It seems that the largest discrepancies occur at low and very high influent TKN/COD ratios, with the ENBNRAS system achieving better COD balances for sewage batches with a very high influent TKN/COD ratio (e.g. sewage batches 15, 19, 26, 27 and 28 with influent TKN/COD ratios of 0.124, 0.116, 0.118, 0.111 and 0.123 respectively), and the UCT system achieving higher COD mass balances for sewage batches with lower influent TKN/COD ratios (e.g. sewage batches 18, 21, 22 and 25 with influent TKN/COD ratios of 0.087, 0.089, 0.107 and 0.085 respectively).

On average over sewage batches 13 to 30, the UCT system influent COD was 735 mgCOD/l and the ENBNRAS system influent COD was 731 mgCOD/l. The overall average influent COD values are within 1% of each other, confirming that the two systems did indeed receive the same feed even though there are minor variations in the influent COD values for each of the separate sewage batches. Figure 3.32 shows the COD removal performance for each of the two systems, as a percentage of the influent COD concentration fed to each system. From Figure 3.32 it can be seen that the COD removal performances of the two systems are virtually identical. The UCT and ENBNRAS systems removed an overall average of 92.8% and 93.5% of the influent COD respectively. While the ENBNRAS system removed 0.7% more COD on average, this difference is negligible. BNRAS systems generally remove COD virtually completely irrespective of configuration and this is clearly demonstrated here.

Figure 3.33 shows the daily oxygen demand of the main aerobic reactors for the UCT and the ENBNRAS systems. The oxygen demand is given in units of mgO/d because, being independent of the reactor volume, it gives a more accurate reflection of the oxygen demand in the respective systems.

Figure 3.33 shows the advantage of the ENBNRAS system in terms of oxygen demand. The UCT system had an average daily oxygen demand of 7625 mgO/d over the 18 sewage batches, while the ENBNRAS had an average daily oxygen demand of only 1798 mgO/d. By nitrifying

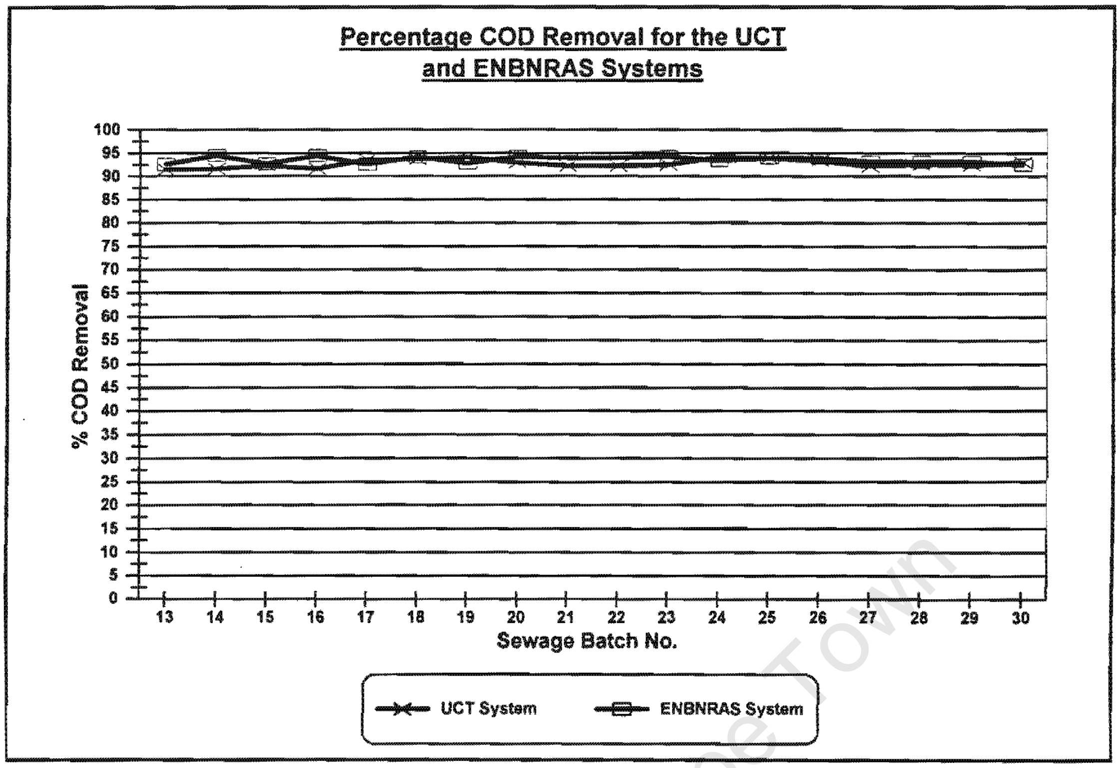

FIGURE 3.32 - Percentage COD removal by the UCT and ENBNRAS systems for sewage batches 13 to 30.

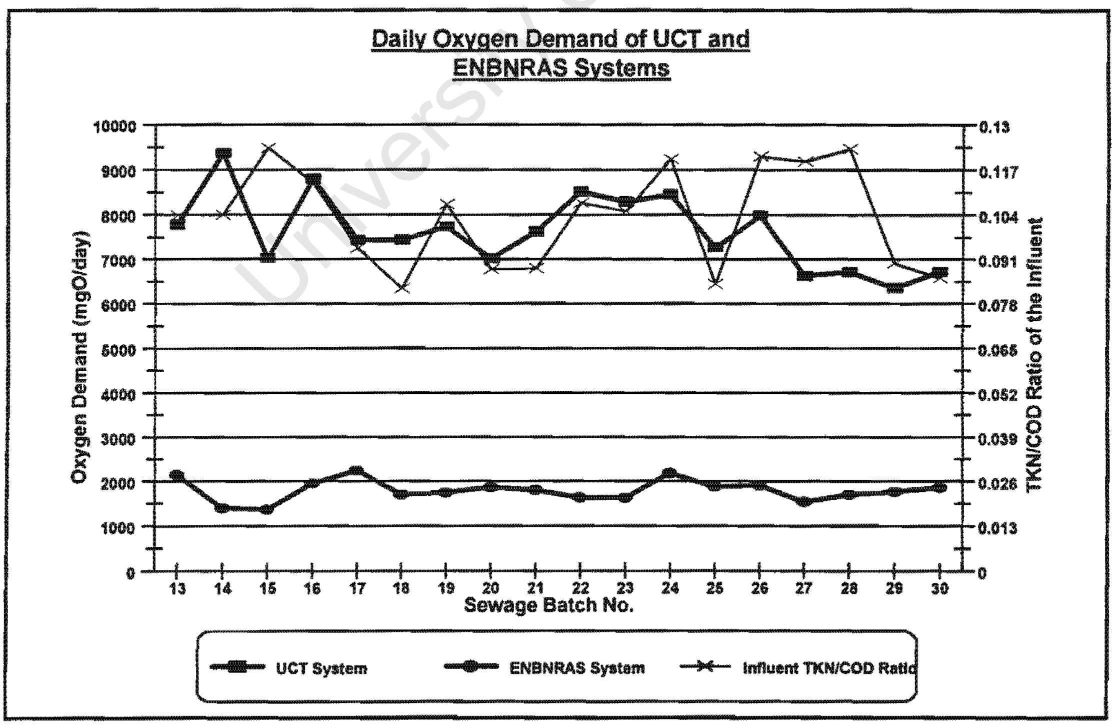

FIGURE 3.33 - Daily oxygen demand for the UCT and ENBNRAS systems for sewage batches 13 to 30.

externally, the ENBNRAS system requires about 76% less oxygen than the UCT system requires with nitrification taking place internally. The influent TKN/COD ratio is included in Figure 3.33 to illustrate the variation of the daily oxygen demand of the UCT system with the variation of the influent TKN/COD ratio. As the influent TKN/COD ratio increases, more nitrate is produced and the daily oxygen demand of the UCT system rises, and vice versa. The daily oxygen demand of the ENBNRAS system does not show the same variation with varying influent TKN/COD ratios because nitrification occurs externally and is not coupled to the oxygen demand of the system. This results in a more constant daily oxygen demand for the ENBNRAS system, which can be seen in Figure 3.33.

A further interesting comparison can be made regarding the VSS concentrations of the two systems. The UCT system had an overall average VSS concentration of 1727 mgVSS/l while the ENBNRAS systems overall average VSS concentration was 1437 mgVSS over sewage batches 13 to 30. The 16.8% lower VSS concentration for the ENBNRAS system almost corresponds to the 18.3% of the influent COD 'lost' to the EN system of the ENBNRAS system. This indicates that the COD that is 'lost' to the EN system is not available to the organisms in the BNRAS system and this will result in the ENBNRAS system containing lower VSS concentrations, roughly in proportion to the fraction of the influent COD that is removed in the EN system and hence 'lost' to the main system.

3.5.2 Nitrogenous Material Removal

Figure 3.34 shows the N mass balances for sewage batches 13 to 30 for the UCT and the ENBNRAS systems. The overall average N mass balance over the 18 sewage batches for the UCT and ENBNRAS systems was 86.1% and 87.0% respectively. As was the case for the COD balances, the results are very close together, albeit considerably higher than the respective COD balances, which is usually the case for NDBEPR systems in the Water Research Laboratory. From Figure 3.34 it can be seen that the N mass balances for the respective sewage batches are similar with marked differences in the N mass balances only occurring for sewage batches 14, 15, 17 and 22. Figure 3.35 shows the overall TKN reduction achieved by the UCT and ENBNRAS systems, as a percentage reduction of the influent TKN. The TKN reduction achieved by the two systems is very similar. The UCT system achieved an overall average TKN reduction of 94.7% and the ENBNRAS system achieved a slightly lower TKN reduction of 93.8%. The reason for the ENBNRAS system achieving a lower value is the FSA concentration in the final effluent. The

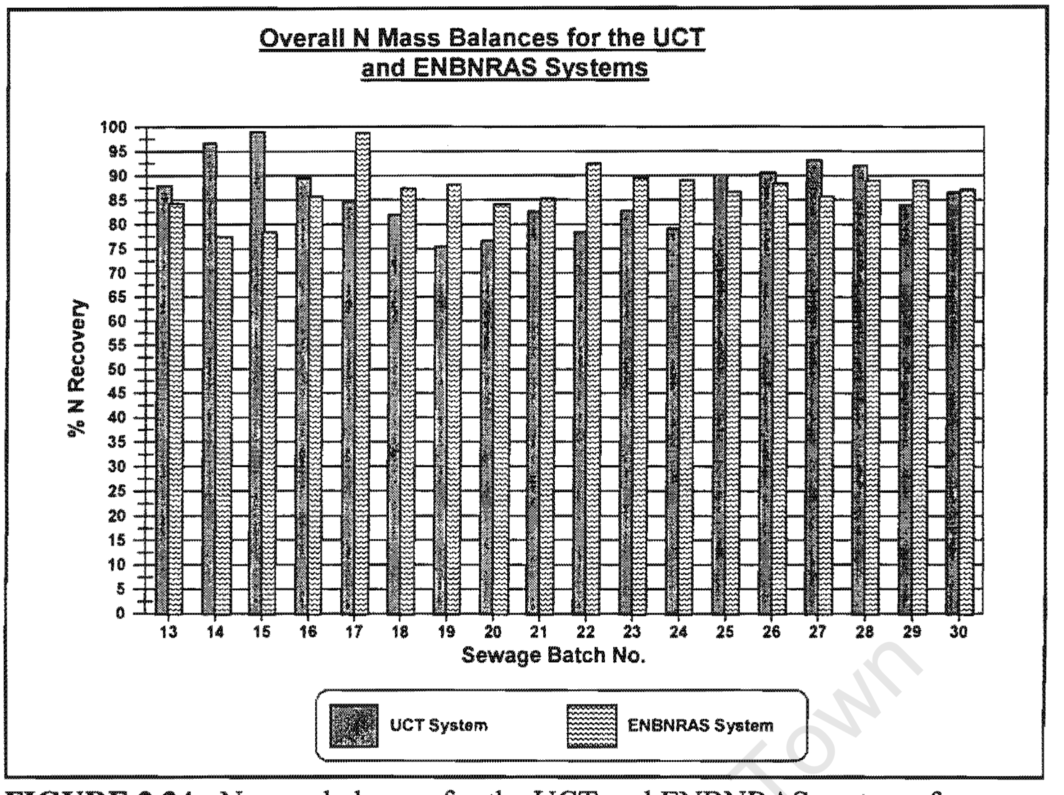

FIGURE 3.34 - N mass balances for the UCT and ENBNRAS systems for sewage batches 13 to 30.

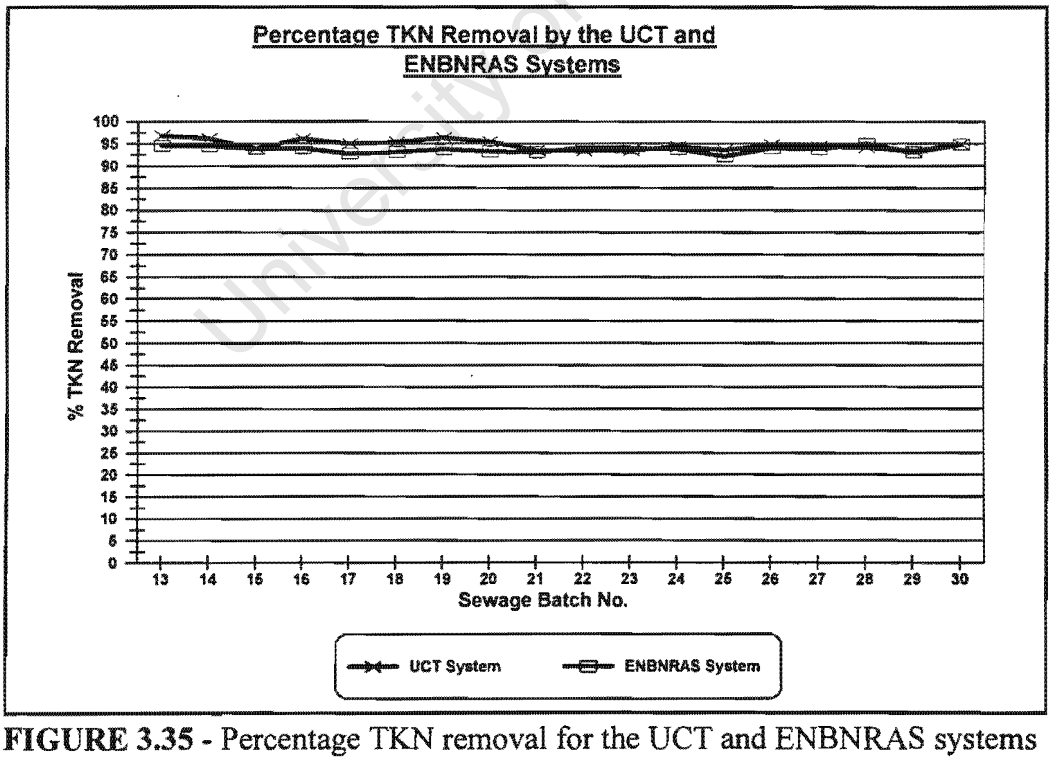

FIGURE 3.35 - Percentage TKN removal for the UCT and ENBNRAS systems for sewage batches 13 to 30.

effluent FSA of the ENBNRAS system was on average over the 18 sewage batches 3.5 mgN/l FSA, while that of the UCT system final effluent was 1.8 mgN/l FSA. The source of this effluent FSA in the ENBNRAS system is the FSA that bypasses the EN system in the sludge bypass, and the FSA that is not nitrified in the main aerobic reactor flows out in the effluent. The concentration of FSA in the EN system outflow of the ENBNRAS system, on average over the 18 sewage batches, was 3.3 mgN/l. This is very similar to the 3.5 mgN/l FSA in the final effluent and indicates that (i) the FSA in the final effluent is approximately equal to the FSA that was not nitrified in the EN system, (ii) the FSA that bypasses the EN system in the EN system sludge bypass is nitrified in the aerobic reactor and (iii) the FSA released in the main anoxic reactor is also nitrified in the aerobic reactor. The nitrifiers are seeded into the activated sludge with the EN system outflow, and this is how the system is intended to operate to maintain a low final effluent FSA.

Figure 3.36 shows the total N concentrations in the effluents of the UCT and the ENBNRAS systems for sewage batches 13 to 30.

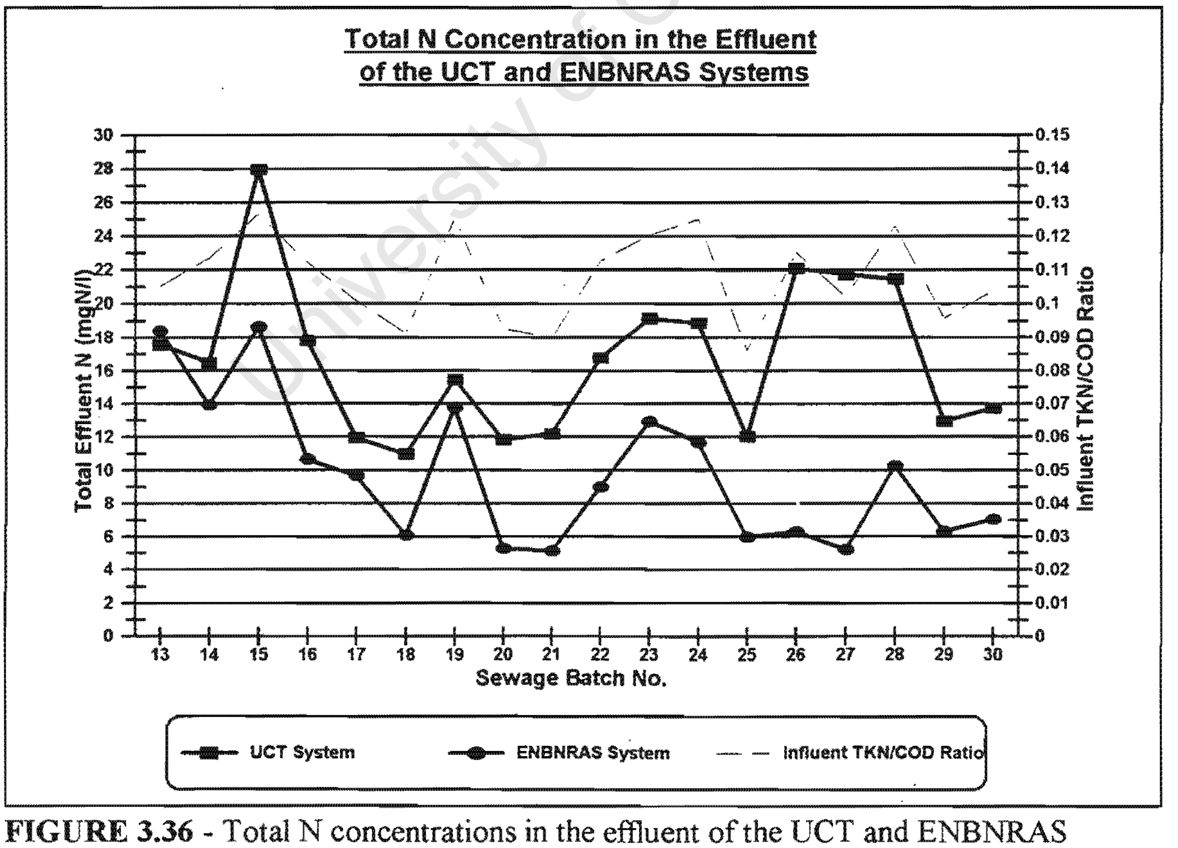

FIGURE 3.36 - Total N concentrations in the effluent of the UCT and ENBNRAS systems and influent TKN/COD ratios for sewage batches 13 to 30.

From Figure 3.36 the difference in the N removal performance of the UCT and the ENBNRAS systems can be seen more clearly. While the TKN measurements take account of only organic N and FSA, the total N represents organic N, FSA, nitrite and nitrate. Figure 3.35 shows that both systems remove TKN equally efficiently, but from Figure 3.36 it can be seen that the ENBNRAS system removes significantly more total N than the UCT system. This means that the ENBNRAS system produces a final effluent with a lower nitrate concentration than the UCT system, because it is the varying concentration of nitrate in the effluent that leads to the variation of the total N in the effluent. On average over sewage batches 13 to 30, the UCT system effluent nitrate was 12.4 mgN/l, while that from the ENBNRAS system was only 4.6 mgN/l of nitrate. This results in the ENBNRAS system having the potential of producing effluents containing <10 mg/l total N, while the UCT system is not capable of achieving similar results[1]. This can also be seen from Figure 3.36: The ENBNRAS system achieved a total N (TN) concentration in the effluent of <10 mgN/l for 10 of the 18 sewage batches, while the UCT system did not once achieve TN concentrations of <10 mgN/l in the effluent. The influent TKN/COD ratio has also been included on Figure 3.36 to illustrate how the variations in the effluent TN concentrations mirror the variations in the influent TKN/COD ratio. On average over the 18 sewage batches, the UCT system effluent TN concentration was 16.7 mgN/l, while that for the ENBNRAS system was 9.8 mgN/l. The main reason for this difference is the potential of the ENBNRAS system to denitrify completely with its larger anoxic mass fraction and its low nitrification in the aerobic reactor. The UCT system cannot denitrify completely because all nitrification takes place in the aerobic reactor.

Figure 3.37 shows the percentage TN removals for the UCT and the ENBNRAS systems for sewage batches 13 to 30. From Figure 3.37 it can be seen that the ENBNRAS system removed a greater percentage N from the influent wastewater than the UCT system for all 18 sewage batches. On average over the 18 sewage batches, the UCT system removed 78.2% of the total influent N and the ENBNRAS system removed 87.8% of the total influent N.

[1] The higher effluent nitrate for the UCT system was due to the smaller anoxic mass fraction. The effluent NO_X could have been reduced somewhat by increasing the a-recycle ratio, but high NO_X concentrations (>3 mgN/l) in the outflow of the anoxic reactor leads to (i) deterioration in sludge settleability and (ii) anoxic P uptake BEPR and lower P removal (see Figures 3.41 and 3.42) below.

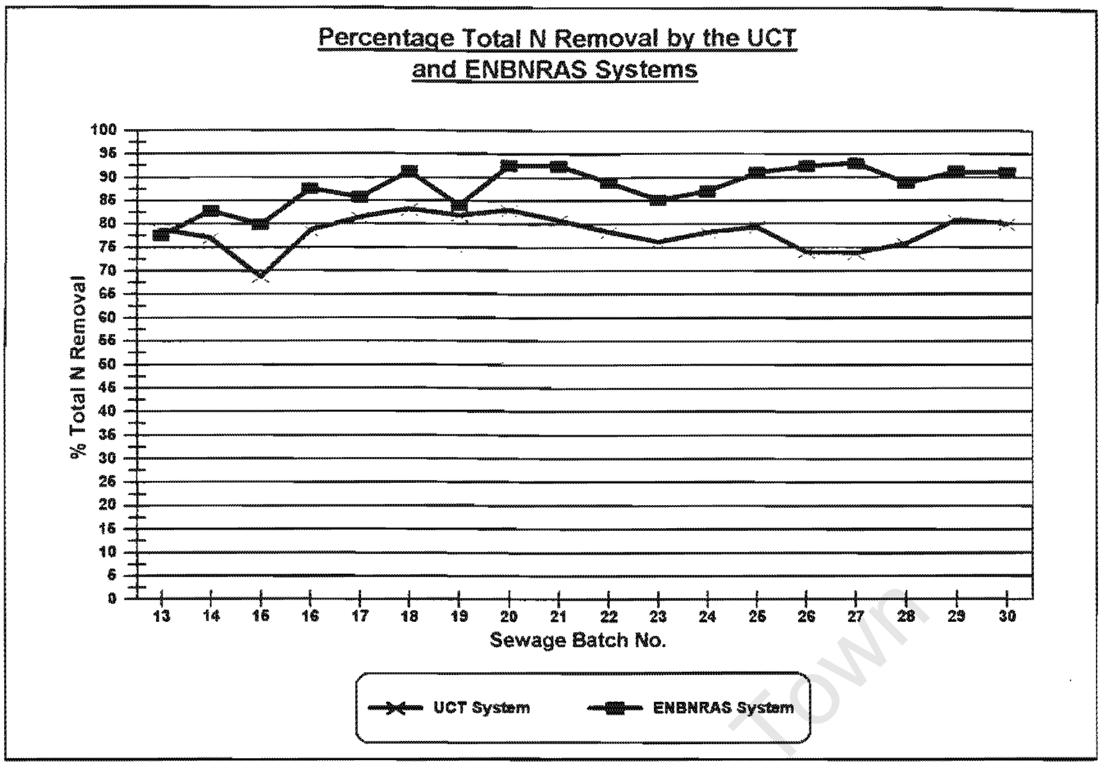

FIGURE 3.37 - Percentage total N removal by the UCT and ENBNRAS systems for sewage batches 13 to 30.

3.5.3 Biological Excess Phosphorus Removal (BEPR)

The ENBNRAS system favours anoxic/aerobic P uptake BEPR, while the UCT system favours aerobic P uptake BEPR. However, when the UCT system is fed sewage with a high influent TKN/COD ratio, which results in a high nitrate load on the main anoxic reactor, anoxic P uptake does occur. For sewage batches 21 to 27 in both systems, the influent TKN/COD ratio was kept consistently high (>0.100) by adding FSA to the influent to induce anoxic P uptake in the UCT system, so that the BEPR performance of the UCT system with anoxic P uptake as well as with predominantly aerobic P uptake could be compared to the BEPR of the ENBNRAS system. Figure 3.38 shows the percentage anoxic P uptake for both the UCT and the ENBNRAS systems for sewage batches 13 to 30.

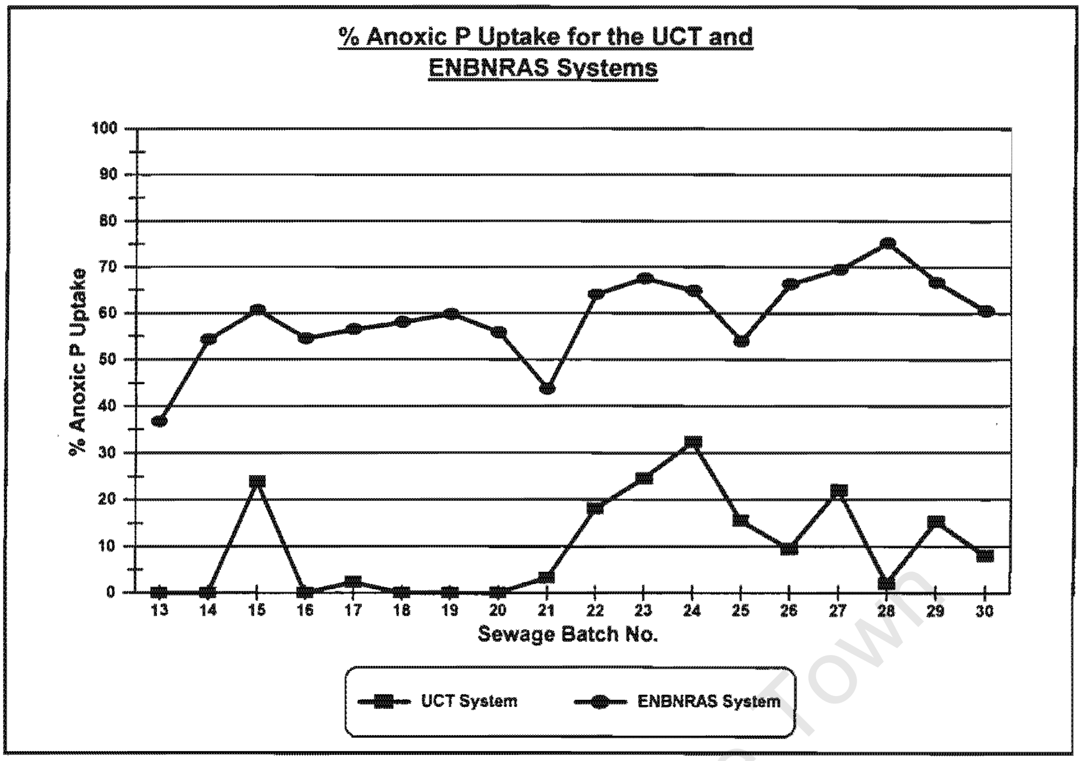

FIGURE 3.38 - Percentage anoxic P uptake for the UCT and ENBNRAS systems for sewage batches 13 to 30.

From Figure 3.38 it can be seen that considerable anoxic P uptake (40 to 70%) occurred in the ENBNRAS system throughout the 18 sewage batches, with an overall average over the 18 sewage batches of ~60%. In the UCT system negligible anoxic P uptake occurred for sewage batches 13 to 21, with the exception of sewage batch 15, which had a very high influent TKN/COD ratio of about 0.123. During sewage batches 21 to 27, where the influent TKN/COD ratio was kept consistently above 0.100 (by dosing FSA to the influent), appreciable anoxic P uptake took place in the UCT system (10 to 30%). However, the anoxic P uptake in the UCT system never reached the same magnitude observed in the ENBNRAS system, and on overall average over the 6 sewage batches (22 to 27) only 20% anoxic P uptake occurred. This shows that the BEPR in the UCT system was essentially aerobic P uptake BEPR. After sewage batches 21 to 27, the FSA dosing to the influent was stopped which lowered the influent TKN/COD ratio and underloaded the anoxic reactor with nitrate, and the system returned to predominantly aerobic P uptake.

Figures 3.39 and 3.40 show the P release and P uptake respectively for the UCT and the ENBNRAS systems over the 18 sewage batches.

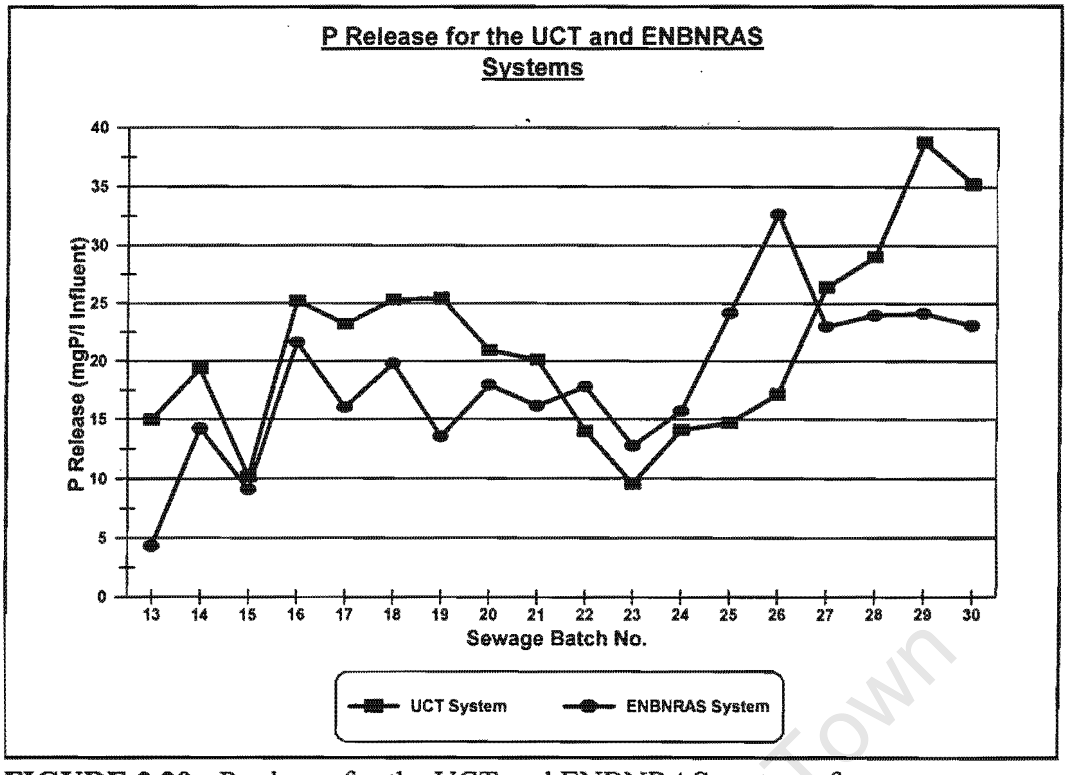

FIGURE 3.39 - P release for the UCT and ENBNRAS systems for sewage batches 13 to 30.

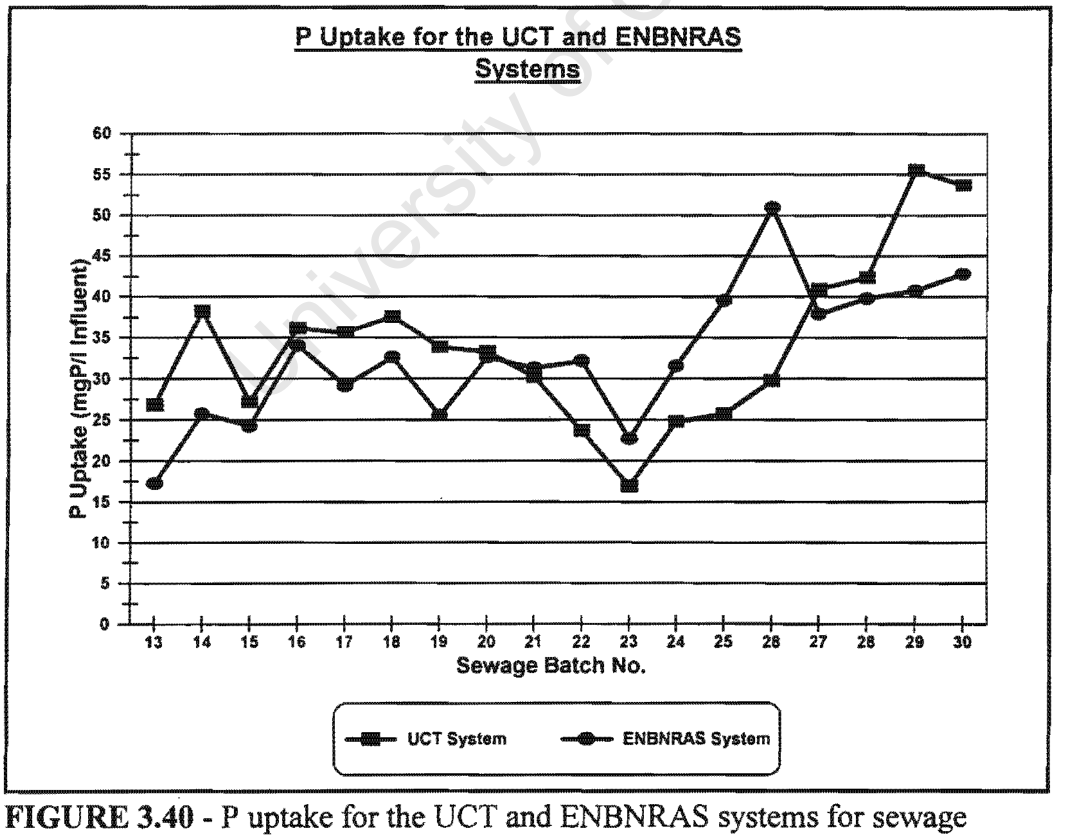

FIGURE 3.40 - P uptake for the UCT and ENBNRAS systems for sewage batches 13 to 30.

On average over all of the 18 sewage batches, the UCT system released 21.3 mgP/l influent and the ENBNRAS system released 18.3 mgP/l influent. From Figure 3.39 it can be seen that for the sewage batches where there was negligible anoxic P uptake in the UCT system (sewage batches 13,14,16 to 20 and 28 to 30) it released on average ~7 mgP/l influent more P than the ENBNRAS system. However, for the sewage batches where there was anoxic P uptake in the UCT system (sewage batches 15 and 21 to 27) the ENBNRAS system released on average ~3 mgP/l influent more P than the UCT system did. Thus, when operating with predominantly aerobic P uptake, the UCT system releases more P than the ENBNRAS system does, even though it has a lower anaerobic mass fraction than the ENBNRAS system. However, when anoxic P uptake takes place in the UCT system, the P release drops to lower levels than in the ENBNRAS system. This shows that with anoxic P uptake BEPR in the UCT system (i) less P is released per unit RBCOD than under aerobic P uptake BEPR and (ii) P release decreases also due to the high nitrate load on the anoxic reactor and nitrate recycle to the anaerobic reactor. From Figure 3.40 it can be seen that the P uptake follows exactly the same trend of the P release. The P uptake for the UCT system was 33.2, 26.9 and 50.5 mgP/l influent for sewage batches 13 to 21 (aerobic P uptake), 22 to 27 (anoxic/aerobic P uptake) and 28 to 30 (aerobic P uptake) respectively. That of the ENBNRAS system was 28.1, 35.8 and 41.1 mgP/l influent respectively, with anoxic/aerobic P uptake throughout. For sewage batches 13 to 21, the UCT system P uptake (predominantly aerobic) was about 5 mgP/l influent higher than that of the ENBNRAS system. For sewage batches 22 to 27, when anoxic/aerobic P uptake occurred in the UCT system (20% anoxic P uptake), the P uptake was about 9 mgP/l influent less than that of the ENBNRAS system (64% anoxic P uptake). For sewage batches 28 to 30, when the P uptake in the UCT system had returned to predominantly aerobic P uptake, the P uptake was 9 mgP/l influent higher than that of the ENBNRAS system. On overall average over the 18 sewage batches, the UCT system P uptake was 34.0 mgP/l influent and that of the ENBNRAS system was 32.8 mgP/l.

Figure 3.41 shows the P removal achieved by the UCT and the ENBNRAS systems for sewage batches 13 to 30. In essence the P removal reflects the combination of those tendencies found for the P release and the P uptake. When the UCT system operates with predominantly aerobic P uptake, on average it removes ~4 mgP/l influent more P than the ENBNRAS system. Under conditions where the UCT system does show anoxic P uptake, the ENBNRAS system removes ~2 mgP/l more P than the UCT system. On overall average over the 18 sewage batches, the UCT system removed 12.7 mgP/l influent, while the ENBNRAS system removed 9.8 mgP/l influent. This shows that under normal circumstances the UCT system with predominantly aerobic P uptake BEPR removes ~23% more P than the ENBNRAS with anoxic P uptake BEPR. If however, the UCT system receives an influent that causes a consistent high nitrate load on its anoxic reactor, anoxic P uptake (to a lesser extent than in the ENBNRAS system) occurs, resulting in poorer P removal performance than the ENBNRAS system can achieve when receiving the same influent.

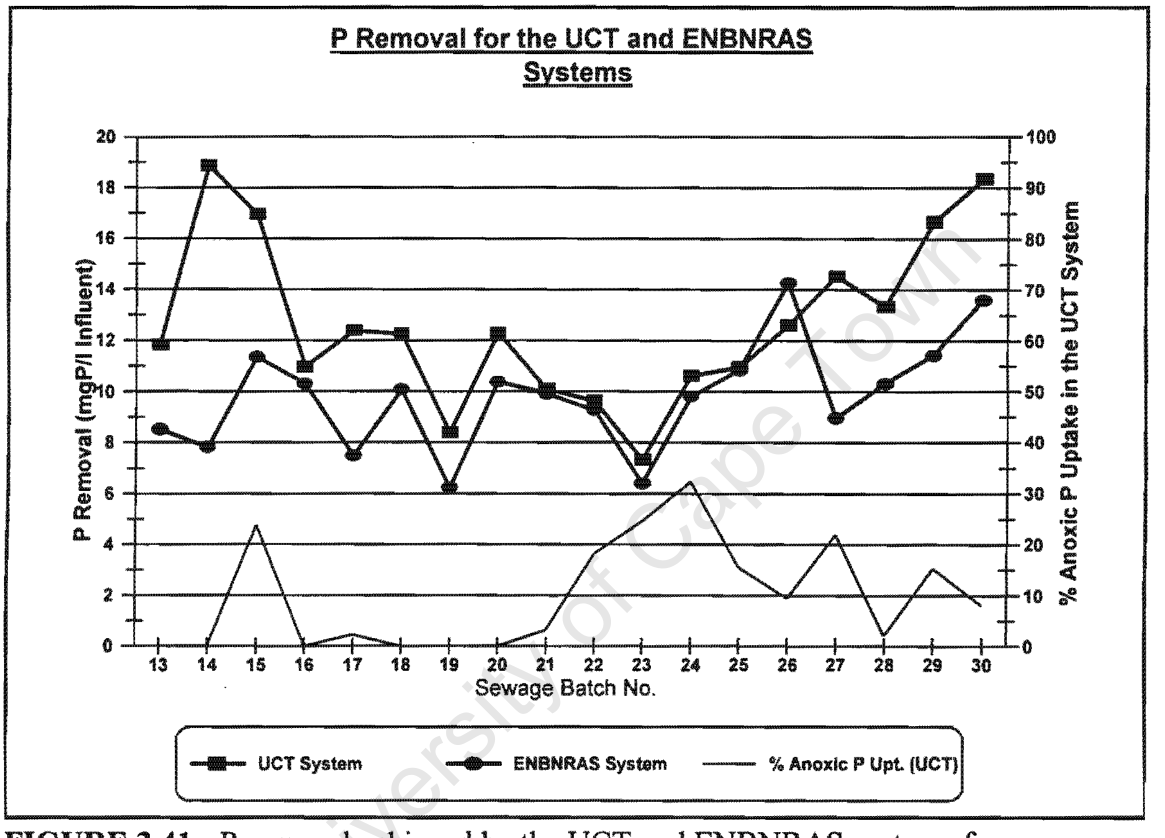

FIGURE 3.41 - P removal achieved by the UCT and ENBNRAS systems for sewage batches 13 to 30.

A more detailed investigation into the anoxic P uptake BEPR of the ENBNRAS system and the aerobic uptake BEPR of the UCT system is given by Vermande *et al.* (2000).

3.5.4 Sludge Settleability

Figure 3.42 shows the DSVI for the UCT and the ENBNRAS systems for sewage batches 13 to 30. The % anoxic P uptake for the UCT system has also been included in the Figure 3.42 to illustrate how the DSVI of the UCT system fluctuates with an increase in % anoxic P uptake. The overall average DSVI of the UCT system over the 18 sewage batches was 138 ml/g and that for the ENBNRAS system was 102 ml/g.

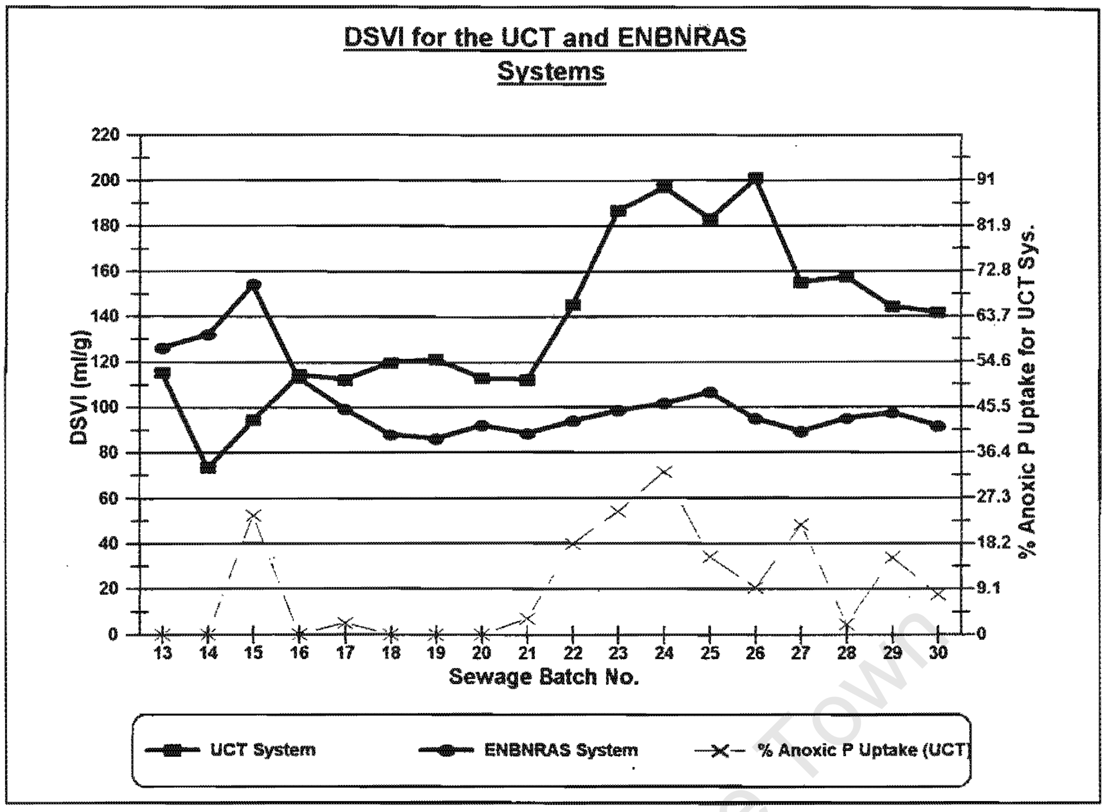

FIGURE 4.42 - DSVI for the UCT and ENBNRAS systems for sewage batches 13 to 30.

From Figure 4.42 it can be seen that the DSVI of the UCT system fluctuates with the % anoxic P uptake. As the % anoxic P uptake increases, the sludge settleability deteriorates rapidly. This can also be seen in another way: As the nitrate load on the anoxic reactor of the UCT system increases the % anoxic P uptake increases; also the nitrate concentration flowing from the anoxic reactor also increases, causing the DSVI to increase (see Casey *et al.*, 1994). From the DSVI of the ENBNRAS system it can be seen that this phenomenon does not occur in the ENBNRAS system. The DSVI of the ENBNRAS does not fluctuate as widely as the DSVI of the UCT system, even though it received the same feed as the UCT system. During sewage batches 21 to 27, where the influent TKN/COD ratio was kept consistently high, the DSVI of the ENBNRAS system increased slightly from around 90 ml/g to around 105 ml/g, while the DSVI of the UCT system responded by increasing sharply from around 110 ml/g to over 200 ml/g. During sewage batches 13, 14 and 15 the UCT system showed a considerably lower DSVI than that of the ENBNRAS system. However, during this period the ENBNRAS system had not yet recovered from the effects of the toxic sewage batch 9, and this was the period where the DSVI of the ENBNRAS system was at its highest (i.e. the sludge settleability was at its worst).

CHAPTER 4

CONCLUSIONS AND DISCUSSION

4.1 INTRODUCTION

Biological nutrient removal activated sludge (BNRAS) systems have become the preferred treatment systems for advanced municipal wastewater treatment in South Africa. They have proven to be cost-effective systems that produce effluents of excellent quality that can be re-introduced to the receiving water bodies without a significant negative impact on the already scarce surface water of South Africa. The widespread implementation of the BNRAS system has drawn attention to some weaknesses of the system, predominantly (i) the long sludge ages and resulting large biological reactor volumes required for nitrification, (ii) filamentous organism bulking of the sludge that develops in the system, (iii) treatment of the P rich waste sludge from the system and (iv) containment of the large mass of P in the sludge during a failure of the aeration in the system. In order to overcome the first two weaknesses of the systems, it is proposed to separate the process of nitrification from the BNRAS mixed liquor and achieve nitrification externally to the BNRAS system.

External nitrification (EN) can be achieved in trickling filters (TFs) by promoting the growth of nitrifying bacteria on the fixed media, which will establish a permanent population of nitrifiers in the TF. With the slow growing nitrifiers effectively removed from the main BNRAS system and nitrification occurring externally in the trickling filters, the requirement to nitrify no longer governs the selection of the sludge age and aerobic mass fraction of the main BNRAS system. The sludge age can therefore be reduced from the usual 20 to 25 days to 8 to 10 days, increasing the capacity of an existing treatment works by about 50% or, alternatively, decreasing the required biological reactor volume per Ml wastewater treated by about ⅓. Furthermore, the unaerated mass fraction can be increased to 70% and above which results in a higher denitrification capacity. If a fraction of the additionally available unaerated mass fraction is added to the anaerobic zone, the BEPR performance will also improve. Casey *et al.* (1994) show that aerobic mass fractions between 25 and 75% are a contributing factor for AA (low F/M) filament proliferation. Because the BNRAS system with external nitrification can have aerobic mass fractions of 30% and less, a better sludge settleability can be expected than is commonly observed in 'conventional' BNRAS systems with 40 to 60% aerobic mass fractions. This improvement in sludge settleability would further increase the wastewater treatment plant capacity.

Two investigations on laboratory scale ENBNRAS systems have been completed (Hu *et al.*, 1999 and Moodley *et al.*, 1999) and were reviewed in Chapter 2. The objectives of this third laboratory investigation into ENBNRAS system performance were to:

(i) Achieve consistent virtually complete EN and obtain steady state conditions for the BNR processes in the BNRAS system in order to confirm the results of the first two investigations for an ENBNRAS system operating at steady state.

(ii) Evaluate anoxic P uptake under steady state conditions.

(iii) Monitor the interaction between anoxic and aerobic P uptake, and to identify the conditions that trigger the shift between anoxic and aerobic P uptake and the effect of this on the overall BEPR performance.

(iv) Compare the overall BNR performance of the ENBNRAS system with that of a 'conventional' BNRAS system (UCT configuration) with equivalent design and operating parameters receiving the identical watewaster as influent.

The laboratory scale ENBNRAS system of this investigation was operated at 10 days sludge age for the first 421 days of the 483 days investigation. During the first 421 days, the system was operated in three different configurations, viz. Configuration 1 from day 1 to day 186 with 0.42 and 0.33 anoxic and aerobic mass fraction respectively; Configuration 2 from day 187 to day 284 with 0.55 and 0.20 anoxic and aerobic mass fraction respectively, and Configuration 3 from day 285 to day 421 with the a-recycle of 2:1 with respect to influent flow removed (0:1). From day 422 to day 470 the ENBNRAS system was operated at 8 days sludge age and a 25% increased influent flow of 25 l/d (Configuration 4), and from day 471 to day 483 the sludge age was reduced further to 5 days (Configuration 5). The configurations with the sludge ages of less than 10 days were included in order to investigate the ENBNRAS system response to these lower sludge ages. A 'conventional' BNRAS system (UCT configuration) with equivalent design and operating parameters (10 days sludge age) was run in parallel with the ENBNRAS system of this investigation for 255 days (from day 167 to day 421) and both systems were fed the same sewage that was prepared together (see Chapter 3 Section 3.5). This was done in order to obtain a meaningful comparison of the performance of the ENBNRAS system with anoxic P uptake BEPR and the 'conventional' BNRAS system with predominantly aerobic P uptake BEPR. The results of this investigation are summarised below in Sections 4.2 to 4.4 and followed by a concluding discussion in Section 4.5.

4.2 SYSTEM PERFORMANCE FOR THE 10 DAYS SLUDGE AGE CONFIGURATION

4.2.1 COD Removal Performance

1. Over the 421 days the system was operated at a 10 days sludge age (Configurations 1, 2 and 3; sewage batches 1 to 30) the overall average COD balance obtained was 80%. Although considerably lower than 100%, the overall average COD balance of 80% is similar to those obtained for the investigations on laboratory scale ENBNRAS systems by Hu *et al.* (1999) and Moodley *et al.* (1999), who obtained COD mass balances of 89 and 80% respectively. Low COD mass balances have been noted for many years in BNR research (McClintock *et al.*, 1988) and it seems that there are biological processes that occur in BNRAS and ENBNRAS systems with high unaerated mass fractions, which consume a fraction of the influent COD but are not taken into account in the COD mass balance. Their existence would explain the consistently lower COD mass balances obtained in the BNRAS and ENBNRAS systems (Ekama and Wentzel, 1999).

2. Of the 100% influent COD, 6.2% flowed from the system with the effluent, 13.8% was passed to oxygen, 12.7% was utilised for NO_X denitrification, 19.7% was removed in the EN system, 26.7% was removed with the waste sludge of the BNRAS system and 20.8% was unaccounted for.

3. The overall average percentage COD removal in the ENBNRAS system was 94% which was slightly higher than the 92 and 91% obtained by Hu *et al.* (1999) and Moodley *et al.* (1999) respectively.

4. The overall average 0.45 μm membrane filtered and unfiltered effluent COD concentrations were 41.8 mgCOD/l and 50.6 mgCOD/l respectively. Based on the former, the unbiodegradable soluble fraction $f_{s,us}$ is 0.057.

5. The overall average TSS and VSS concentrations in the ENBNRAS system were 1653 mgTSS/l and 1369 mgVSS/l, giving an average VSS/TSS ratio of 0.83.

6. The average oxygen utilisation rate (OUR) for Configuration 1 was 22.4 mgO/(l.hr), 18.3 mgO/(l.hr) for Configuration 2 and 18.7 mgO/(l.hr) for Configuration 3. Configuration 1 shows a higher OUR, because the aerobic mass fraction for Configuration 1 was 0.33, while the aerobic mass fraction was lower at 0.2 for both Configurations 2 and 3.

4.2.2 Nitrogenous Material Removal Performance

7. The overall average N mass balance obtained for the ENBNRAS system was 88%. This is similar to the N mass balances of 91% obtained by both Hu *et al.* (1999) and Moodley *et al.* (1999) for the investigations on their ENBNRAS systems.

8. Of the 100% influent N, 13.7% flowed from the system with the effluent, 44.3% was denitrified, 11.7% was removed in the EN system, 17.6% was removed with the waste sludge of the BNRAS system and 12.0% was unaccounted for. The 11.7% of N removed in the EN system is more than reasonably can be expected to be incorporated in the sludge mass for growth in the EN system. During the investigation, nitrogen gas bubbles were noted in the piping of the EN system and in internal settler B (which led to occasional rising sludge in internal settler B), and this indicates that denitrification in the EN system in part explains the unexpectedly high N removal in the EN system.

9. On average, 89% of the FSA flowing into the EN system was nitrified to nitrate. Of the total nitrification occurring in the ENBNRAS system, on average 87% occurred in the EN system, i.e. externally to the BNRAS system. For the ENBNRAS system of Moodley *et al.* (1999), 88% of the FSA flowing into the EN system was nitrified, and about 76% of the ENBNRAS system nitrification occurred externally. Hu *et al.* (1999) reported that for the ENBNRAS system of his investigation, 88% of the ENBNRAS system nitrification occurred externally. The above indicated that an EN system nitrifies up to about 90% of the FSA that is passed through it, i.e. 100% nitrification does not occur. Furthermore, nitrification cannot be totally excluded from the main BNRAS system, and around 10 to 13% of the ENBNRAS system nitrification remains in the aerobic reactor of the BNRAS system.

10. The overall average denitrification potential of the main anoxic reactor of the ENBNRAS system was 22.0 mgN/l influent for Configuration 1 (main anoxic reactor mass fraction of 0.33), 19.0 mgN/l influent for Configuration 2 (main anoxic reactor mass fraction of 0.45) and 31.1 mgN/l influent for Configuration 3 (main anoxic reactor mass fraction of 0.45). The pre-anoxic reactor had an overall average denitrification potential of 4.5 mgN/l influent for Configurations 1, 2 and 3 (pre-anoxic reactor mass fraction of 0.1). Because Configuration 2 had a larger main anoxic reactor mass fraction, the denitrification potential for Configuration 2 should have been higher than that of Configuration 1. However, a toxic sewage batch (sewage batch 9) had an adverse effect on the system denitrification performance, and this effect resulted in very low denitrification potentials for the main anoxic reactor for sewage batches 9 to 15. Sewage batches 9, 10, 11, 12 and 13 correspond to Configuration 1, while sewage batches 14 and 15 correspond to Configuration 2. Ten denitrification potentials (sewage batches with >1 mgN/l in the outflow of the main anoxic reactor) could be calculated for Configuration 1, but only 5 for Configuration 2. The very low denitrification potentials caused by the toxic batch of sewage therefore had a pronounced effect on the average denitrification potential of Configuration 2, resulting in a denitrification potential lower than that of Configuration 1. Configuration 3 (a-recycle ratio of 0:1 and the same main anoxic mass fraction of Configuration 2) showed the highest denitrification potential for the main anoxic reactor, indicating that the a-recycle, which causes the sludge to be exposed to more frequent alternating anoxic / aerobic conditions, has a detrimental effect on the denitrification performance of the main anoxic reactor.

11. The denitrification of the ENBNRAS system was distributed through the system as follows: Of the overall average denitrification that occurred in the ENBNRAS system, 11.0% occurred in the pre-anoxic reactor, 10.0% in the anaerobic reactor, 77.4% in the main anoxic reactor and 1.6% in the final settling tank. The 10.0% denitrification in the anaerobic reactor was largely due to the low denitrification in the main anoxic reactor during sewage batches 9 to 15 caused by the toxic sewage fed in sewage batch 9. With the low denitrification in the main anoxic reactor during this time, high concentrations of nitrate were recycled to the pre-anoxic reactor, overloading it and causing the nitrate to flow into the anaerobic reactor. This also had a negative impact on the P release in the anaerobic reactor, and hence on BEPR, which is discussed in Section 4.2.3 below.

12. The overall average TKN removal of the ENBNRAS system was 94%, and the overall average total N (TN) removal was about 86%. The ENBNRAS system effluent contained 11.9 mgN/l TN on overall average, of which 5.2 mgN/l was TKN (unfiltered samples), 5.8 mgN/l nitrate and 0.9 mgN/l nitrite (both filtered samples). Of the 5.2 mgN/l TKN, 3.6 mgN/l was FSA (unfiltered samples). The filtered TKN was 4.3 mgN/l, and hence 0.7 mgN/l was soluble organic N; accepting this to be unbiodegradable organic N yields an unbiodegradable soluble TKN fraction (f_{nu}) of 0.01. The overall average nitrate concentration of 5.8 mgN/l in the effluent is a result of the poor denitrification performance caused by the toxic sewage batch 9 and also a consequence of a few sewage batches having a very high (~0.14) influent TKN/COD ratio. For Configuration 3, which produced the best N and P removal performance for the 10 days sludge age system, the effluent TN was 8.0 mgN/l, of which 4.8 mgN/l was TKN (unfiltered sample), 3.6 mgN/l FSA (unfiltered sample), 2.8 mgN/l nitrate and 0.4 mgN/l nitrite (both unfiltered samples). The ENBNRAS system therefore shows that it is capable of (i) producing effluents with a TN content of <10 mgN/l, and (ii) complete denitrification in the main anoxic reactor (not zero effluent nitrate) for influent TKN/COD ratios of up to about 0.13. Comparatively, Hu *et al.* (1999) and Moodley *et al.* (1999) reported TN removals in their ENBNRAS systems of 86% and 72% respectively.

4.2.3 Biological Excess Phosphorus Removal Performance

13. The overall average P release for the ENBNRAS system was 12.6 mgP/l influent (58% of total P release) in the anaerobic reactor, 4.7 mgP/l influent (22%) in the internal settler A and 4.5 mgP/l influent (20%) in the EN system. The P release in the EN system is unlikely to be coupled with SCFA uptake by the PAOs and hence its benefit to the BEPR in the main BNRAS system is questionable. It is more likely a P release through endogenous decay of PAOs that do not settle in the internal settler A and enter the EN system, or a breakdown in the EN system of filterable (because this P does not reflect in the filtered P of the internal settler supernatant) but non settleable (because it does not settle out in internal settler A) organics containing P. Of the two, the former is less likely because PAOs are strongly flocculent and settle well, but then 4.7 mgP/l influent release from non settleable but filterable organics does not seem very likely either. The P release that occurred in the EN system is not included in any BEPR calculations but it does represent P that needs to be taken up again in the main anoxic and aerobic reactors.

14. The overall average P uptake for the BNRAS system was 33.1 mgP/l influent. The P uptake occurred exclusively in the main anoxic and main aerobic reactors, with negligible uptake in the final settling tank. P uptake did occur in the pre-anoxic reactor when the nitrate load on it was high, and P release occurred when near zero concentrations of nitrate flowed into the pre-anoxic reactor, but both were negligible (<1 mgP/l influent) concentrations. On overall average, 62 and 38% of the total P uptake occurred in the main anoxic and aerobic reactors respectively.

Throughout the investigation, the % anoxic P uptake varied between 26 and 75%. The anoxic P uptake appears to be linked to the nitrate load on the main anoxic reactor. When the anoxic reactor was overloaded with nitrate (>1 mgN/l in the outflow of the main anoxic reactor), up to 75% of the total system P uptake occurred in the main anoxic reactor. When the main anoxic reactor was underloaded with nitrate (i.e. <0.5 mgN/l in its outflow), the % anoxic P uptake decreased and the % aerobic P uptake increased. As the % anoxic P uptake decreased and the % aerobic P uptake increased, the P removal appeared to increase. This indicates that as the % P uptake shifts from anoxic to aerobic with a decrease in nitrate load on the main anoxic reactor, improved P removal occurs. However, it is difficult to quantify this improvement in P removal, because the periods of maximum % anoxic P uptake and minimum aerobic P uptake (showing low P removal) were the same periods with the highest nitrate load on the main anoxic reactor leading to nitrate recycle into the anaerobic reactor. It is therefore difficult to conclude to what extent the nitrate leaking into the anaerobic reactor reduced the P removal (by adversely affecting the P release) and by what extent the high % anoxic P uptake affected the P removal. Anoxic P uptake can be stimulated in the ENBNRAS system due to its large anoxic and small aerobic mass fractions, but the extent to which it occurs is dependent on the nitrate load on the main anoxic reactor. A steady state % anoxic P uptake is therefore difficult to reach; the % anoxic P uptake will increase or decrease as the nitrate load on the main anoxic reactor is above or below the denitrification potential of the main anoxic reactor. Moreover, if the aerobic reactor is small and the anoxic reactor large and significantly underloaded with nitrate, BEPR will be adversely affected because anoxic P uptake is limited by the nitrate load on the anoxic reactor and the aerobic reactor is too small to complete the P uptake process. Effective exploitation of anoxic P uptake for

BEPR therefore demands a sufficiently high nitrate load on the main anoxic reactor.[1]

15. The overall average P removal of the ENBNRAS system was 9.8 mgP/l influent. This compares well with the values obtained for the ENBNRAS systems of Hu *et al.* (1999) and Moodley *et al.* (1999) who reported 8.8 mgP/l influent and 10.4 mgP/l influent respectively for the same influent COD concentration (~750 mgCOD/l) and wastewater source. On average, the three ENBNRAS systems removed about 39% less P than would be expected from a similar 'conventional' BNRAS system with no anoxic P uptake.

16. The ENBNRAS system $P_{release}/P_{removal}$, $P_{removal}$/Influent COD and $P_{removal}$/Influent RBCOD ratios were 1.82, 0.013 and 0.069. Ekama and Wentzel (1999) reported that with significant anoxic P uptake BEPR, the $P_{release}/P_{removal}$, $P_{removal}$/Influent COD and $P_{removal}$/Influent RBCOD ratios are lower at 1.5 - 2.0, 0.012 - 0.015 and 0.06 - 0.08 respectively, compared with predominantly aerobic P uptake BEPR. The values obtained for the ENBNRAS system of this investigation fall within the indicated ranges for significant anoxic P uptake BEPR.

17. The unbiodegradable particulate fraction of the influent sewage ($f_{s,up}$) was calculated by the method outlined by Ekama and Wentzel (1999) and applied in all BEPR investigations undertaken in the Water Research Laboratory at the University of Cape Town (viz. Wentzel *et al.*, 1990; Clayton *et al.*, 1991; Musvoto *et al.*, 1992; Kashula *et al.*, 1993; Pilson *et al.*, 1995; Sneyders *et al.*, 1998; Mellin *et al.*, 1998; Hu *et al.*, 1999 and Moodley *et al.*, 1999). The method 'fractionates' theoretically the measured VSS into active OHO and PAO, endogenous OHO and PAO and particulate unbiodegradable concentrations. It requires selecting by trial and error the appropriate $f_{s,up}$ so that the system VSS mass calculated with the BEPR model of Wentzel *et al.* (1990) is equal to that measured in the BNRAS system. For this investigation the $f_{s,up}$ was calculated for two

[1] It appears that interest in anoxic P uptake arose in an effort to 'recapture' the influent RBCOD for denitrification in NDBEPR systems. With aerobic P uptake, the influent RBCOD is lost for denitrification because the PAOs which have taken up this COD in the anaerobic reactor utilise it only in the aerobic reactor. With anoxic P uptake, the PAOs utilise this COD in the anoxic reactor. While this 'recaptures' the RBCOD for denitrification, it appears this is at a cost of reduced BEPR. It will be argued later when presenting PAO denitrification rates and comparing the anoxic P uptake BEPR in the ENBNRAS system with the aerobic P uptake BEPR in the UCT system, that anoxic P uptake BEPR is not advantageous - it contributes little to the denitrification but causes a significant decrease in BEPR.

scenarios, (i) reducing the influent COD by the COD 'lost' in the EN system only, and (ii) reducing the influent COD by the COD 'lost' in the EN system as well as the COD unaccounted for in the COD mass balances, but keeping the influent RBCOD concentration unchanged at that measured. This implies that the COD lost to the BNRAS part of the system is all from the slowly biodegradable (SB) COD fraction. An average $f_{s,up}$ for (i) of 0.040 and for (ii) of 0.126 was found. From the $f_{s,up}$ values obtained from ND systems, which yield good (>95%) COD balances and consistent $f_{s,up}$ values (Mellin *et al.*, 1998 - Section 4.3.1), the $f_{s,up}$ calculated for (ii) is a more realistic value for the Mitchells Plain wastewater. It seems that the COD unaccounted for in the COD mass balances is indeed utilised by other biological processes that occur in BNRAS and ENBNRAS systems with high unaerated mass fractions, which consume a fraction of the influent COD. The P content of the PAOs was calculated by a similar method, and an average $f_{xbg,p}$ for (i) of 0.20 and for (ii) of 0.24 was found.

18. The overall average OHO and PAO denitrification rates ($K_2''_{OHO}$ and $K_2''_{PAO}$) were also calculated for the scenarios (i) and (ii) in 17 above. From the VSS fractionation calculation, the concentration of influent RBCOD obtained by the PAOs is known, with the balance of the influent RBCOD and the influent SBCOD available to the OHOs. To determine the contribution of the PAOs to the denitrification in the anoxic reactor, it is assumed that the total P uptake in the anoxic and aerobic zones result in the utilisation of all the RBCOD obtained by the PAOs and that the % P uptake in the anoxic and aerobic zones reflects the % PAO RBCOD utilised in these respective zones. Thus, with say 40% anoxic P uptake, 40% of the influent RBCOD obtained by PAOs is utilised in the anoxic zone and 60% in the aerobic zone. The % anoxic P uptake is calculated from the experimental data on the BNR systems. With the COD concentration utilised by the PAOs in the anoxic reactor known, the nitrate denitrified with this COD in the PAO anoxic growth process can be calculated via the anoxic growth yield coefficient ($Y_{Ganoxic}$) and the oxygen equivalent of nitrate , i.e. 2.86 mgO/mgN denitrified. In this calculation it was accepted that $Y_{Ganoxic}$ is equal to the aerobic value viz. $Y_{Ganoxic}$ = 0.45 mgPAOAVSS/mgPHBCOD utilized.[2] With the nitrate concentration denitrified by the

[2] Strictly $Y_{Ganoxic}$ should be lower than the equivalent aerobic value because under anoxic conditions ideally only 2 moles ATP are formed per pair of electrons transferred, whereas under aerobic conditions 3 moles of ATP are formed per pair of electrons transferred; from bioenergetic calculations, this reduces $Y_{Gaerobic}$ = 0.45 to $Y_{Ganoxic}$ = 0.38 mgPAOAVSS/mgPHBCOD utilised.

PAOs calculated, the nitrate concentration denitrified by the OHOs is the difference between the observed nitrate concentration denitrified in the anoxic reactor and the nitrate concentration denitrified by the PAOs. The specific denitrification rate of the PAOs and OHOs, viz. $K_2"_{PAO}$ and $K_2"_{OHO}$, is then obtained by dividing the calculated nitrate denitrification rate of the PAOs and OHOs by the active PAO and OHO VSS concentrations determined from the VSS fractionation calculation. In this way the observed denitrification rate is apportioned and expressed in terms of the specific organism group mediating denitrification. This steady state model can be applied only to anoxic reactors overloaded with nitrate, i.e. having significant nitrate concentrations in their outflow to ensure that the biological OHO and PAO denitrification potential is exceeded. The $K_2"_{OHO}$ and $K_2"_{PAO}$ rates were found to be 0.0564 mgN/(mgOHOAVSS.d) and 0.0374 mgN/(mgPAOAVSS.d) respectively for scenario (i) and 0.1239 mgN/(mgOHOAVSS.d) and 0.0374 mgN/(mgPAOAVSS.d) respectively for scenario (ii). Accepting scenario (ii) as the more realistic of the two, the contribution of the PAOs to denitrification is not very large, only about 23% to the total denitrification process. If the denitrification in the ENBNRAS system were attributed to the OHOs alone and the measured VSS theoretically fractionated into OHO, endogenous OHO and unbiodegradable particulate VSS concentrations (as in Clayton *et al.,* 1991), then the unadjusted K_2' is 0.1548 mgN/(mgAVSS.d) for scenario (ii). This K_2' rate cannot be compared with the rates listed by Ekama and Wentzel (1999) because in calculating these listed values, the influent COD concentration was not reduced by the unaccounted for COD as in this investigation, and the influent unbiodegradable particulate COD fraction ($f_{s,up}$) was kept constant (at 0.12).

4.2.4 Filament Identification and Sludge Settleability Throughout the Investigation

19. The main filamentous organisms identified in the ENBNRAS system were *Microthrix parvicella* (with an average abundance level between 'some' and 'common'), type 1851 (with an average abundance level of 'some'), type 0092 (with an average abundance level of 'some') and *H.hydrossis* (with an average abundance level of 'few').

20. The overall average DSVI of the ENBNRAS system was about 108 ml/g. This is higher than the DSVI's of 60 ml/g and 94 ml/g of the ENBNRAS systems of Hu *et al.* (1999)

and Moodley *et al.* (1999) respectively. The overall average DSVI of 108 ml/g for the ENBNRAS system of this investigation was a result of poor sludge settleability during the period the system was affected by the toxic sewage fed during sewage batch 9. After the system recovered from the toxic sewage (from sewage batch 15 onwards) the DSVI stabilised to around 90 ml/g, which is lower than the overall average DSVI of 108 ml/g. The ENBNRAS system appears not to produce bulking sludges even when high nitrate concentrations flow from the anoxic reactor, which is stated as one of the causes of bulking in 'conventional' BNRAS systems as described in the AA filament sludge bulking hypothesis by Casey *et al.* (1994) provided the aerobic mass fraction is between 25 and 60%. The ENBNRAS system does seem to respond to the high nitrate concentrations flowing from the main anoxic reactor by an increase in DSVI, but this increase is limited to about 20 ml/g.

4.3 SYSTEM PERFORMANCE FOR THE 8 AND 5 DAY SLUDGE AGE CONFIGURATIONS (CONFIGURATIONS 4 AND 5)

The ENBNRAS system configuration was changed to shorter sludge ages and increased influent flow towards the end of the investigation. The system was operated in Configuration 4 (8 days sludge age and 25 instead of 20 l/d influent flow) for 49 days (sewage batches 31 to 33) and in Configuration 5 (5 days sludge age and 25 l/d influent flow) for a further 13 days (sewage batch 34). The system configuration was changed to the shorter sludge ages to evaluate the response to and performance of the ENBNRAS system to the shorter sludge ages.

21. The overall average COD mass balances for the 8 and 5 day sludge age configurations (4 and 5 respectively) of the ENBNRAS system were 79 and 92% respectively and the overall average COD removals (based on unfiltered COD samples) 93 and 90% respectively. Although lower than the overall average COD removal of 94% achieved by the 10 days sludge age configuration, the COD removal performances of the short sludge age configurations are still very good. The slightly lower values are most likely due to the hydraulic impact on the final settler caused by the increase in influent flow, rather than due to the system removing less COD.

22. The overall average N mass balances attained for the 8 and 5 day sludge age configurations were 85 and 95% respectively. For the 8 and 5 day sludge age

configurations, 88 and 96% of the FSA flowing into the EN system was nitrified. On average, 93 and 95% of the ENBNRAS system nitrification was effected externally for the 8 and 5 day sludge age configurations respectively. This demonstrates one of the main benefits of the ENBNRAS system configuration - virtually complete nitrification at 8 and 5 days sludge age with only 0.20 aerobic mass fraction, and this will be attainable also at temperatures lower than 20°C.

23. The overall average denitrification potential of the main anoxic reactor was about 46 and 34 mgN/l influent for the 8 and 5 day sludge age configurations respectively. These are higher than observed at ten days sludge age, even when the system denitrification was greatest (i.e. Configuration 3, 31 mgN/l).

24. The overall average TKN removal for the ENBNRAS system operated at the 8 and 5 day sludge age configurations were 94 and 92% respectively. The TN removal was 92 and 76% respectively. The discrepancies in the TN removals for the 8 and 5 day sludge age configurations are due to the average influent TKN/COD ratios of the sewage batches fed to the two configurations; for the 8 day sludge age configuration this was 0.096, while for the 5 day sludge age configuration it was much higher at 0.120. The higher influent TKN/COD ratio and lower denitrification potential of the 5 day sludge age configuration led to more nitrate in the effluent, and therefore to a lower TN removal.

25. The overall average P removal for the 8 day sludge age configuration was 14.0 mgP/l influent. For the 5 day sludge age configuration this was 8.6 mgP/l influent. The 8 day sludge age configuration removed 4.2 mgP/l influent more than the 10 days sludge age configuration, showing that there is indeed an improvement in BEPR as the sludge age is decreased as reflected in the BEPR model of Wentzel *et al.* (1990). It would therefore be expected that the 5 day sludge age would show a further improved BEPR performance; however, for the 5 day sludge age configuration, high nitrate concentrations were recycled to the pre-anoxic reactor, which was consequently overloaded, causing nitrate to enter the anaerobic reactor, which in turn caused a decrease in P release and hence a decrease in P removal. The nitrate recycle was due to the high influent TKN/COD ratio (0.12) and reduced main anoxic reactor performance.

26. The overall average % anoxic P uptake for the 8 day sludge age configuration was 47% (with a nitrate load of 20.7 mgN/l on the main anoxic reactor), and the overall average % anoxic P uptake for the 5 day sludge age configuration was 58% (with a nitrate load of 34.9 mgN/l on the main anoxic reactor). This shows clearly that as the nitrate load on the main anoxic reactor increases, the % anoxic P uptake increases.

27. The overall average DSVI for the 8 and 5 day sludge age configurations were about 90 ml/g and 93 ml/g respectively. For the 8 day sludge age configuration <1 mgN/l flowed out of the main anoxic reactor, but for the 5 day sludge age configuration about 15 mgN/l flowed out of the main anoxic reactor. Good sludge settleability at sludge ages less than 10 days (8, 6 and 5 days sludge age) has been observed in intermittently aerated ND systems by Warburton *et al.* (1991) and Phoredox, 3 stage Bardenpho, UCT and JHB BEPR systems (Burke *et al.*, 1986). The AA (low F/M) filament bulking hypothesis (Casey *et al.*, 1994) is not considered to be applicable at 3 to 8 days sludge age because the AA filaments are slow growers that tend to proliferate in long sludge age (>8d) systems.

A detailed analysis of the results of the 8 and 5 day sludge age configurations is not intended, as the system performance evaluation at these shorter sludge ages lasted for only 62 days. However, the results show that the ENBNRAS system BNR performance in no way deteriorated at the shorter sludge ages, in fact a reduction in sludge age tends to increase N and P removal per mass of organic load (Wentzel *et al.*, 1990), provided that it is not reduced below a lower limit of about 5 days for operational reasons (sludge flocculation, effluent turbidity).

4.4 COMPARISON OF THE ENBNRAS SYSTEM WITH A 'CONVENTIONAL' BNRAS SYSTEM (UCT CONFIGURATION)

A laboratory scale 'conventional' BNRAS system (UCT configuration) with similar design and operating parameters to the 10 days sludge age ENBNRAS system of this investigation was run in parallel with the laboratory scale ENBNRAS system. To compare the performance of the two systems, both were fed identical influent sewage for 255 days spanning 18 sewage batches (from 13 to 30). For the purpose of directly comparing the BNR performance of the two systems, the overall averages for the ENBNRAS system are the overall averages of sewage batches 13 to 30, not the overall averages of sewage batches 1 to 30. The overall averages presented in this section therefore differ from those calculated for the entire 10 days sludge age configuration as discussed under Section 4.2 above. A detailed discussion of this comparison is given by Vermande *et al.* (2000).

28. The overall average COD mass balance achieved for the UCT and ENBNRAS systems were 78 and 77% respectively. The COD removal was 93 and 94% respectively. In terms of carbonaceous material removal, the two systems performed identically.

29. The overall average total oxygen demand (including nitrification) of the UCT system was 7625 mgO/d while that of the ENBNRAS system was 1798 mgO/d. By nitrifying externally, the ENBNRAS system requires 76% less oxygen per day; this is a significant difference.

30. The overall average N mass balance for the UCT and ENBNRAS systems were 86 and 87% respectively and the overall average TKN removal 95 and 94% respectively. The effluent TN of the UCT system was 16.8 mgN/l, of which 12.8 mgN/l was NO_X (filtered sample) and 4.0 mgN/l was TKN (unfiltered sample). Of the 4.0 mgN/l TKN, 1.8 mgN/l was FSA (unfiltered sample). For the ENBNRAS system the effluent TN was 9.8 mgN/l, of which 4.6 mgN/l was nitrate (filtered sample) and 5.2 mgN/l was TKN (unfiltered sample). Of the 5.2 mgN/l TKN 3.5 mgN/l was FSA (unfiltered sample). The ENBNRAS system achieved effluent TN concentrations <10 mgN/l in 10 out of the 18 sewage batches, while the UCT system did not achieve effluent TN concentrations <10 mgN/l in any of the 18 sewage batches. The overall average TN removal for the UCT and ENBNRAS systems were 78 and 88% respectively.

31. In the UCT system an overall average of 21.3 mgP/l influent P was released in the anaerobic reactor. In the ENBNRAS system an overall average of 18.3 mgP/l influent P was released in the anaerobic reactor and internal settler A, with an additional P release of 4.5 mgP/l influent in the EN system (which also has to be taken up in the anoxic and aerobic reactors). On overall average, 34.0 mgP/l influent P uptake occurred in the UCT system, and 32.8 mgP/l influent P uptake occurred in the ENBNRAS system.

32. The overall average P removal for the UCT system was 12.7 mgP/l influent (34.0 - 21.3), and the overall average P removal for the ENBNRAS system was 9.8 mgP/l influent (32.8 - 4.7 - 18.3). The UCT system showed only 9.8% anoxic P uptake on overall average, showing that predominantly aerobic P uptake BEPR occurred in the UCT system. In the ENBNRAS system, 60% of the P uptake occurred in the main anoxic reactor. During sewage batches 21 to 27 anoxic P uptake was induced in the UCT system by feeding influent sewage with high TKN/COD ratios (leading to a high nitrate load on the anoxic reactor). During this period the UCT system showed about 18% anoxic P uptake and the P removal decreased to the same level as measured in the ENBNRAS system.

33. The overall average DSVI for the UCT and ENBNRAS system were 138 ml/g and 103 ml/g respectively. During sewage batches 21 to 27, where sewage with a high influent TKN/COD ratio were fed to induce anoxic P uptake in the UCT system, the DSVI of the UCT system increased sharply from around 110 ml/g to over 200 ml/g, while the DSVI of the ENBNRAS system increased only slightly from around 90 ml/g to around 105 ml/g. This shows that the 'conventional' BNRAS system reacts much more strongly to significant (>2 mgN/l) nitrate concentrations in the outflow of the main anoxic reactor because its aerobic mass fraction is higher (0.5) than that of the ENBNRAS system (0.2). This response to nitrate in the outflow of the main anoxic reactor was also observed by Moodley *et al.* (1999) in their ENBNRAS system with a higher aerobic mass fraction (0.30), which conforms to the AA filament sludge bulking hypothesis of Casey *et al.* (1994) (see Chapter 2, Section 2.3.4).

In terms of carbonaceous material removal, the UCT and the ENBNRAS system achieve almost identical results. For the nitrogenous material removal, the ENBNRAS system consistently produces an effluent of better quality, with an effluent TN concentration of nearly half that of the UCT system on overall average. The ENBNRAS system produced an effluent with a TN content <10 mgN/l for 10 out of the 18 sewage batches, while the UCT system did not achieve this for any sewage batch. The UCT system, which exhibited predominantly aerobic uptake BEPR, removed about 3 mgP/l influent more P than the ENBNRAS system with anoxic/aerobic P uptake BEPR did. P removal is the only process where the UCT system achieves superior results to that of the ENBNRAS system. The ENBNRAS system BNR is effected by using approximately 75% less oxygen than was required by the UCT system to perform the same BNR. The ENBNRAS system produced a better settling sludge than the UCT system did, and the ENBNRAS system

DSVI did not produce a bulking sludge when high nitrate concentrations flowed from the anoxic reactor, as was observed in the UCT system.

4.5 CLOSURE

The investigations on laboratory scale ENBNRAS systems by Hu *et al.* (1999), Moodley *et al.* (1999) and this investigation show that BNRAS system intensification by separating the process of nitrification from the main BNRAS system and effecting nitrification externally is possible in practice. The EN systems implemented in the three laboratory scale ENBNRAS system investigations nitrified between about 85 and 90% of the FSA flowing into them, indicating that they do not nitrify 100% of the FSA passed through them. In addition, it seems that it is not possible to obtain 100% of the ENBNRAS system nitrification externally. Up to 90% of the total system nitrification can occur externally, but residual nitrification (of the FSA not nitrified in the EN system and the FSA in the sludge bypass) will occur in the main aerobic reactor.

The laboratory scale ENBNRAS systems removed >90% of the influent carbonaceous material utilising on average about 70% less oxygen than an equivalent 'conventional' BNRAS system. The ENBNRAS systems have shown excellent TKN and very good TN removals (TKN removals >90%, TN removals >80%), and it has been shown that the ENBNRAS systems are capable of producing effluents with TN concentrations of <10 mgN/l for influent wastewaters with TKN/COD ratios of up to between 0.13 and 0.14.

The BEPR occurring in the BNRAS systems is undoubtably anoxic/aerobic P uptake BEPR with the anoxic reactor effecting up to 60 - 70% of the total system P uptake. The magnitude of the anoxic uptake BEPR is dependant on the nitrate load on the main anoxic reactor. If the nitrate load is equal to or below the denitrification potential of the main anoxic reactor, the % anoxic P uptake will decrease and the % aerobic P uptake will increase provided the aerobic mass fraction is sufficiently large to complete the P uptake process. Conversely, when the nitrate load on the main anoxic reactor is greater than the denitrification potential of the main anoxic reactor, the % anoxic P uptake will increase, and the % aerobic P uptake will decrease. As the P uptake shifts from predominantly anoxic P uptake to increased aerobic P uptake, the total P removal seems to increase. It appears that a steady state in terms of anoxic P uptake is not reached, as the P uptake shifts from anoxic P uptake to aerobic P uptake and vice versa, as the nitrate load on the main anoxic reactor increases or decreases. It would therefore not be advisable to implement aerobic mass fractions much smaller than 0.20; even though it is theoretically possible to do so, it would be detrimental to the overall BEPR. The P removal in the ENBNRAS systems is about ⅓ less than in a similar 'conventional' BNRAS system with predominantly aerobic uptake BEPR. The ENBNRAS systems produce sludges that settle very well (from about 70 to 110 ml/g) and it seems that they are not affected to the same extent as 'conventional' BNRAS systems are by high nitrate concentrations flowing from the main anoxic reactor, as stated in the AA filament bulking hypothesis of Casey *et al.* (1994).

It has further been demonstrated that the ENBNRAS systems perform full and uncompromised BNR for short sludge ages down to about 5 days. Conversely the influent flow can be doubled to an existing system without a negative impact on the BNR, provided the system does not fail hydraulically due to the increased influent sewage flow. Sludge ages below 10 days have an added advantage in that N and P removals increase per mass of organic load (Wentzel *et al.*, 1990) as the sludge age is reduced.

The comparison of the laboratory scale ENBNRAS system of this investigation with a laboratory scale 'conventional' BNRAS system (UCT configuration) demonstrated that the carbonaceous material removal performance of both systems was effectively equal. The TN removal performance of the ENBNRAS system was superior to that of the UCT system, in that the ENBNRAS system produced effluents with half the TN concentrations of the UCT system final effluent. The results of the ENBNRAS system showed further that the ENBNRAS is capable of producing effluents with TN concentrations of <10 mgN/l, while this is not the case for the UCT system. Furthermore, the ENBNRAS system is able to perform total denitrification in the main anoxic reactor, while this was not possible for the UCT system because of the limitation imposed by the a-recycle.

The UCT system showed higher BEPR than the ENBNRAS system. With predominantly aerobic P uptake BEPR occurring in the UCT system, it removed on average 3 mgP/l influent more P than the ENBNRAS system. With the anoxic/aerobic P uptake BEPR that occurred in the ENBNRAS system, about 23% less P was removed than in the UCT system.

The ENBNRAS system produced a sludge with a DSVI of between 90 and 100 ml/g, while the DSVI of the UCT system fluctuated between 80 and 200 ml/g. This difference becomes particularly apparent when very high nitrate concentrations flow from the anoxic reactor of the

UCT system. The UCT systems DSVI responded to the high nitrate concentrations flowing from the anoxic reactor with a sharp increase in DSVI from about 100 ml/g to about 200 ml/g, while the ENBNRAS system sludge DSVI increased from around 90 ml/g to just over 100 ml/g at significant nitrate concentrations in the outflow of the main anoxic reactor. The UCT system is hence much more sensitive to AA filament bulking with significant nitrate concentrations in the outflow of the anoxic reactor than the ENBNRAS system. This is because the aerobic mass fraction of the UCT system was 0.50 and within the range of applicability of the AA filament bulking hypothesis of Casey *et al.* (1994).

The investigations on the three laboratory scale ENBNRAS systems provide a comprehensive framework for the understanding of the ENBNRAS system operation and performance, and further laboratory investigations would not provide more knowledge and understanding. The next step would be to begin full scale trials of an ENBNRAS system. To begin with, a full scale trickling filter would have to be converted into a nitrifying trickling filter to ascertain its performance as a nitrifying trickling filter at full scale. Once it has been proven that existing full scale trickling filters can successfully be converted to nitrifying trickling filters and their capacity determined, the trickling filters can be integrated into a BNRAS system in an ENBNRAS system configuration to obtain BNR on the full influent wastewater flow.

Initially it was thought that the savings in capital cost brought about by an increased capacity or smaller biological reactors, reduced oxygen demand and better settling sludge would make the ENBNRAS system an attractive and viable alternative as a full scale plant. The economic evaluation of Little *et al.* (2000) however indicates that this may not be the case. While the ENBNRAS system alternative does provide a saving in construction costs of about 30% when compared to a 'conventional' BNRAS system, the operating costs in the long run overshadow this saving. The operating costs of a sewage treatment works, whether ENBNRAS or 'conventional' BNRAS system, account for the bulk of the net present value (NPV). While significant savings in operation costs are made from the very low oxygen demand, the increased sludge production at the shorter sludge ages and the associated increase in sludge treatment, transport and disposal costs reduce these savings. While the total NPV (capital, operation and maintenance) for the ENBNRAS system option is 5 to 10% lower than that of a 'conventional' BNRAS system, this difference may not be large enough for a definite choice of the ENBNRAS system over the 'conventional' BNR system. However, the most significant advantage is that the ENBNRAS system offers biological N and P removal for the full wastewater flow without increase in existing process units. If the Department of Water Affairs and Forestry implement the proposed new effluent quality standards promulgated under the National Water Act of 1998, the ENBNRAS will provide a feasible and economical plant upgrade option. While the ENBNRAS system does not provide a large enough saving in monetary terms to make it an attractive alternative, the new effluent quality standards may favour the ENBNRAS system. The ENBNRAS system is capable of producing effluents with a quality that are within the new effluent quality standards, especially with regards to nitrogen. The proposed new effluent quality standards rather than economics may well be the driving force that will see the ENBNRAS system implemented at full scale.

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APPENDIX A

TABLE A1 - Explanation of abbreviations used.

UI	Unfiltered Influent
FFI	Floc Filtered Influent
PreANO	Pre-Anoxic Reactor
AN	Anaerobic Reactor
SETA	Internal Settler A
SETB	Internal Settler B
ANO	Main Anoxic Reactor
AE	Main Aerobic Reactor
R	Macerated Mixed Liquor
UE	Unfiltered Effluent
FE	Filtered Effluent

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
1	22-Feb-99	-	-	78.0	150.0	2180.0	30.0	30.0	66.1	196.0	3.6	-	45.4	14.7	9.2	3.6	-
2	23-Feb-99	752.0	280.0	100.0	56.0	2480.0	36.0	36.0	63.7	147.0	4.9	4.5	34.7	14.6	9.2	6.0	0.085
3	24-Feb-99	820.0	316.0	106.0	74.0	2180.0	50.0	50.0	53.2	231.0	9.8	2.0	38.9	16.7	5.5	2.1	0.065
4	25-Feb-99	788.0	156.0	82.0	42.0	2700.0	30.0	30.0	55.3	-	3.4	3.2	38.9	17.6	7.3	2.0	0.070
5	26-Feb-99	No Test (SET 2 blocked up, sludge loss)															
6	27-Feb-99	No Test (AE, ANO & SET 2 overflowed, sludge loss)															
7	28-Feb-99	No Test (AE & SET 2 blocked, overflowed, sludge loss)															
8	01-Mar-99	712.0	160.0	100.0	68.0	2120.0	56.0	40.0	58.8	193.2	4.1	4.1	44.0	18.2	3.2	3.2	0.083
9	02-Mar-99	756.0	124.0	114.0	66.0	1980.0	42.0	66.0	65.2	138.6	3.5	3.1	39.2	20.7	2.7	1.5	0.086
10	03-Mar-99	716.0	164.0	162.0	94.0	1260.0	46.0	38.0	48.4	156.8	3.2	3.2	39.2	14.1	11.9	3.1	0.068
11	04-Mar-99	No Test (SmANO,ANO & AE overflowed, sludge loss) - New sewage fed today															
BATCH 1 Averages:		***757.3***	***200.0***	***106.0***	***78.6***	***2128.6***	***41.4***	***41.4***	***58.7***	***177.1***	***4.6***	***3.3***	***40.0***	***16.7***	***7.0***	***3.1***	***0.076***
12	05-Mar-99	No Test (New Sewage)															
13	06-Mar-99	No Test (New Sewage)															
14	07-Mar-99	No Test: SLUDGE FOUND IN SEWAGE - GET NEW BATCH															
15	08-Mar-99	No Test: (New Sewage Fed Today)															
BATCH 2 Averages:		***BAD BATCH***															
16	09-Mar-99	No Test (New Sewage)															
17	10-Mar-99	No Test (New Sewage)															
18	11-Mar-99	600.0	136.0	156.0	96.0	2600.0	144.0	96.0	77.7	44.8	4.3	4.2	60.8	26.7	8.1	3.2	0.130
19	12-Mar-99	No Test															
20	13-Mar-99	No Test															
21	14-Mar-99	653.3	228.5	150.3	94.2	1663.3	138.3	34.1	106.7	89.6	-	6.3	76.4	38.2	7.7	5.3	0.163
22	15-Mar-99	489.0	152.3	104.2	64.1	2124.2	72.1	68.1	74.6	77.0	4.8	4.8	54.6	24.5	6.6	4.2	0.153
23	16-Mar-99	No Test (AN overflowed violently)															
24	17-Mar-99	613.2	132.3	94.2	58.1	1703.4	66.1	66.1	74.1	-	3.4	3.4	58.5	22.8	5.7	2.8	0.121
25	18-Mar-99	673.3	288.6	184.4	124.2	1923.8	84.2	84.2	97.0	74.2	5.3	5.3	64.4	29.3	8.1	3.8	0.144
BATCH 3 Averages:		***605.8***	***187.5***	***137.8***	***87.3***	***2003.0***	***100.9***	***69.7***	***86.0***	***71.4***	***4.4***	***4.8***	***62.9***	***28.3***	***7.3***	***3.9***	***0.142***
26	19-Mar-99	No Test (New Sewage)															
27	20-Mar-99	No Test (New Sewage)															
28	21-Mar-99	No Test (SmANO,AN & AE overflowed - Sludge Loss)															
29	22-Mar-99	749.5	212.4	198.4	66.1	1583.2	50.1	50.1	86.7	100.8	8.5	7.8	63.0	31.5	18.1	5.6	0.116
30	23-Mar-99	729.5	200.4	224.4	84.2	1563.1	56.1	48.1	83.2	77.0	9.8	8.0	65.2	29.4	22.3	6.3	0.114
31	24-Mar-99	No Test (Install new freezer & spray SET1 black because of algae growth)															

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
32	25-Mar-99	705.4	224.4	216.4	72.1	2004.0	52.1	52.1	89.3	124.6	10.9	9.8	69.4	34.9	22.7	8.0	0.127
33	26-Mar-99	No Test															
34	27-Mar-99	No Test															
35	28-Mar-99	777.6	224.4	208.4	68.1	2044.1	48.1	48.1	88.8	130.2	7.4	4.6	66.9	33.5	21.0	4.1	0.114
36	29-Mar-99	977.7	193.9	218.2	76.8	1858.4	64.6	64.6	92.0	-	10.9	10.9	69.2	34.7	25.5	7.0	0.094
37	30-Mar-99	No Test (Influent bucket run dry)															
38	31-Mar-99	No Test (Dregs of last sewage fed yesterday) - New sewage fed today															
BATCH 4 Averages:		***787.9***	***211.1***	***213.2***	***73.5***	***1810.6***	***54.2***	***52.6***	***88.0***	***108.2***	***9.5***	***8.2***	***66.8***	***32.8***	***21.9***	***6.2***	***0.113***
39	01-Apr-99	No Test (New Sewage)															
40	02-Apr-99	No Test (New Sewage)															
41	03-Apr-99	No Test															
42	04-Apr-99	No Test (SmANO & Nitrifier overflowed - Sludge loss)															
43	05-Apr-99	634.3	173.7	204.0	54.5	1919.0	62.6	50.5	71.3	124.6	4.3	3.6	53.2	25.6	6.3	2.8	0.112
44	06-Apr-99	No Test (Final settler failed - sludge in effluent)															
45	07-Apr-99	No Test (Final settler failed - sludge in effluent)															
46	08-Apr-99	No Test (Final settler failed - sludge in effluent)															
47	09-Apr-99	662.6	169.7	173.7	40.4	1656.4	40.4	40.4	74.5	109.2	4.2	2.1	54.6	26.6	4.8	1.7	0.112
48	10-Apr-99	No Test (External Nitrifier overflowed - big sludge loss)															
49	11-Apr-99	592.3	139.8	154.7	78.0	1628.1	49.7	37.6	71.4	121.8	6.6	-	57.1	28.8	15.3	4.6	0.121
50	12-Apr-99	-	-	153.5	84.8	1696.8	60.6	56.6	72.7	112.0	6.0	5.3	56.3	27.3	7.8	4.5	-
51	13-Apr-99	569.6	157.6	155.5	78.8	1555.4	50.5	38.4	72.4	103.6	6.2	3.9	54.6	25.6	6.4	2.1	0.127
52	14-Apr-99	Cleaned Unit															
53	15-Apr-99	561.6	198.0	103.0	58.6	1232.2	38.4	30.3	72.8	109.2	6.7	5.5	56.3	24.6	6.7	2.9	0.130
54	16-Apr-99	638.3	185.8	177.8	68.7	1373.6	48.5	36.4	76.6	124.6	6.7	0.0	66.1	26.3	6.4	2.0	0.120
BATCH 5 Averages:		***609.8***	***170.8***	***160.3***	***66.3***	***1580.2***	***50.1***	***41.4***	***73.1***	***115.0***	***5.8***	***3.4***	***56.9***	***26.4***	***7.7***	***2.9***	***0.120***
55	17-Apr-99	No Test (New Sewage)															
56	18-Apr-99	No Test (New Sewage)															
57	19-Apr-99	836.3	246.4	272.7	82.8	1717.0	62.6	54.5	81.2	89.6	-	3.8	64.1	25.1	8.1	3.6	0.097
58	20-Apr-99	No Test (AE & ANO overflowed - sludge loss)															
59	21-Apr-99	No Test (ANO & Nitrifier overflowed - sludge loss)															
60	22-Apr-99	771.6	282.8	238.4	64.6	2100.8	68.7	52.5	81.3	131.6	5.2	6.3	64.7	29.0	11.2	4.2	0.105
61	23-Apr-99	No Test															
62	24-Apr-99	No Test															
63	25-Apr-99	No Test (ANO overflowed - sludge loss)															

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
64	26-Apr-99	No Test															
65	27-Apr-99	770.0	176.1	213.0	204.8	1761.3	67.6	36.9	80.9	109.2	4.9	3.9	57.4	27.0	7.0	1.5	0.105
66	28-Apr-99	614.4	188.4	208.9	73.7	1843.2	49.2	45.1	83.2	117.6	4.5	3.9	63.3	27.7	10.6	3.1	0.135
67	29-Apr-99	741.4	200.7	129.0	71.7	2027.5	47.1	47.1	81.3	114.8	4.9	3.5	63.0	28.1	4.9	2.1	0.110
BATCH 6 Averages:		***746.7***	***218.9***	***212.4***	***99.5***	***1890.0***	***59.0***	***47.2***	***81.6***	***112.6***	***4.9***	***4.3***	***62.5***	***27.4***	***8.4***	***2.9***	***0.111***
68	30-Apr-99	No Test (New Sewage)															
69	01-May-99	No Test (New Sewage)															
70	02-May-99	No Test (Nitrifier blocked, overlowing - sludge loss)															
71	03-May-99	696.3	163.8	167.9	69.6	1843.2	73.7	65.5	57.8	121.8	3.4	2.2	38.1	18.5	3.5	1.3	0.083
72	04-May-99	704.5	188.4	176.1	49.2	1925.1	77.8	77.8	59.5	120.4	2.9	2.7	49.0	20.7	1.7	2.1	0.084
73	05-May-99	733.2	127.0	190.5	34.8	1822.7	30.7	30.7	56.1	130.2	3.4	2.7	42.3	21.8	2.2	2.1	0.077
74	06-May-99	806.9	127.0	161.8	51.2	1822.7	47.1	47.1	59.5	117.6	3.5	2.9	43.4	21.7	2.4	1.8	0.074
75	07-May-99	651.3	127.0	145.4	43.0	1658.9	38.9	34.8	53.8	113.4	3.9	2.8	40.6	19.3	2.5	2.2	0.083
76	08-May-99	No Test															
77	09-May-99	598.0	131.1	147.5	45.1	1761.3	45.1	45.1	55.0	121.8	4.3	3.2	41.4	18.6	2.5	2.8	0.092
78	10-May-99	708.6	127.0	165.9	51.2	1577.0	43.0	43.0	57.0	113.4	3.1	2.9	43.7	19.6	2.4	2.1	0.080
79	11-May-99	709.6	137.1	165.3	40.3	1653.1	32.3	32.3	60.6	117.6	4.1	4.1	50.1	22.1	2.7	2.1	0.085
80	12-May-99	673.3	157.2	175.4	139.1	1592.6	50.4	50.4	60.6	109.2	3.6	3.5	45.4	21.1	2.2	2.0	0.090
81	13-May-99	665.3	149.2	171.4	106.8	1350.7	26.2	26.2	60.9	119.0	4.5	4.3	44.8	22.7	3.9	3.9	0.092
82	14-May-99	No Test (New Sewage Fed today)															
BATCH 7 Averages:		***694.7***	***143.5***	***166.7***	***63.0***	***1700.7***	***46.5***	***45.3***	***58.1***	***118.4***	***3.7***	***3.1***	***43.9***	***20.6***	***2.6***	***2.2***	***0.084***
83	15-May-99	No Test (New Sewage)															
84	16-May-99	822.5	177.4	165.3	56.4	1451.5	56.4	56.4	77.3	98.0	4.5	3.6	60.5	28.1	2.8	2.8	0.094
85	17-May-99	758.0	193.5	169.3	56.4	1290.2	72.6	68.5	77.1	102.2	6.3	4.5	61.6	29.1	3.4	4.2	0.102
86	18-May-99	822.5	161.3	181.4	52.4	1330.6	44.4	44.4	80.5	99.4	4.3	4.1	58.2	27.4	3.6	3.5	0.098
87	19-May-99	No Test (Batch Test 1 for Phosphates)															
88	20-May-99	No Test (Batch Test 1 for Phosphates)															
89	21-May-99	No Test															
90	22-May-99	No Test															
91	23-May-99	No Test (Batch Test 2 for Phosphates)															
92	24-May-99	758.0	193.5	193.5	76.6	1653.1	68.5	56.4	81.8	134.4	5.0	4.8	62.7	30.1	2.9	2.9	0.108
93	25-May-99	701.6	185.5	197.6	68.5	1290.2	72.6	68.5	77.1	114.8	4.5	3.4	61.6	28.0	2.8	2.8	0.110
94	26-May-99	717.7	193.5	205.6	60.5	1169.3	52.4	52.4	77.8	92.4	4.9	3.5	63.3	30.4	3.4	3.2	0.108
95	27-May-99	782.2	193.5	209.7	64.5	1088.6	48.4	48.4	79.2	100.8	5.7	3.9	62.7	30.0	2.8	2.8	0.101

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
96	28-May-99	No Test															
97	29-May-99	No Test															
98	30-May-99	No Test (Dregs of last sewage fed yesterday) - New sewage fed today															
BATCH 8 Averages:		***766.1***	***185.5***	***188.9***	***62.2***	***1324.8***	***59.3***	***56.4***	***78.7***	***106.0***	***5.0***	***4.0***	***61.5***	***29.0***	***3.1***	***3.2***	***0.103***
99	31-May-99	No Test (New Sewage)															
100	01-Jun-99	No Test (New Sewage)															
101	02-Jun-99	765.1	157.9	228.7	70.8	1275.1	66.8	66.8	65.9	93.8	9.2	7.3	51.2	26.5	17.4	6.7	0.086
102	03-Jun-99	No Test - Bad batch - Feed new sewage today															
BATCH 9 Averages:		***BAD BATCH***															
103	04-Jun-99	No Test (New Sewage)															
104	05-Jun-99	No Test (New Sewage)															
105	06-Jun-99	825.8	194.3	226.7	93.1	1376.3	64.8	64.8	62.6	88.2	11.6	10.5	49.3	23.9	18.6	9.1	0.076
106	07-Jun-99	809.6	153.8	238.8	121.4	1173.9	64.8	64.8	62.6	98.0	12.5	12.5	47.3	25.3	19.0	9.2	0.077
107	08-Jun-99	769.1	186.2	230.7	133.6	1214.4	68.8	44.5	63.8	89.6	12.2	12.2	48.2	25.5	17.1	10.6	0.083
108	09-Jun-99	785.3	178.1	307.6	392.7	1376.3	89.1	56.7	62.6	98.0	11.8	11.2	48.4	25.9	19.6	8.4	0.080
109	10-Jun-99	No Test															
110	11-Jun-99	No Test - SmANO overflowed															
111	12-Jun-99	No Test															
112	13-Jun-99	Cleaned Unit															
113	14-Jun-99	No Test - (recouperate) - DO Probe & Box installed on Nitrifier															
114	15-Jun-99	No Test - Replace both DO boxes, re-install, service & calibrate probes															
115	16-Jun-99	829.8	174.1	139.7	62.7	1558.5	78.9	78.9	65.4	100.8	15.8	14.1	51.5	24.8	15.4	13.2	0.079
116	17-Jun-99	795.6	194.8	134.7	80.8	1595.4	89.1	68.4	62.2	110.6	13.6	11.8	49.0	22.5	13.4	10.1	0.078
117	18-Jun-99	No Test															
118	19-Jun-99	No Test															
119	20-Jun-99	849.5	186.5	151.3	80.8	1139.6	64.2	64.2	64.7	85.4	4.5	3.8	51.8	20.3	9.1	3.1	0.076
120	21-Jun-99	791.5	194.8	134.7	43.5	891.0	31.1	18.6	63.1	96.6	4.2	4.1	49.3	19.3	5.0	2.1	0.080
121	22-Jun-99	820.5	149.2	128.5	74.6	1243.2	58.0	58.0	65.9	89.6	6.9	5.3	50.1	19.6	7.7	5.3	0.080
122	23-Jun-99	816.4	145.0	134.7	47.7	891.0	55.9	35.2	63.4	72.8	3.1	2.7	47.6	19.3	3.6	2.1	0.078
123	24-Jun-99	No Test - Hydraulics Invidulation															
124	25-Jun-99	No Test -Exam															
125	26-Jun-99	No Test -Exam															
126	27-Jun-99	No Test -Exam															
127	28-Jun-99	802.3	172.4	131.8	73.8	1442.1	53.0	44.8	62.0	84.0	4.1	3.6	47.6	22.1	2.8	3.1	0.077

		mgCOD/l							mgN/l									
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
128	29-Jun-99	No Test															
129	30-Jun-99	774.9	169.9	213.4	89.1	1181.0	43.5	43.5	63.1	84.0	3.5	3.5	43.4	21.1	2.8	2.8	0.081
130	01-Jul-99	795.6	182.3	136.8	70.4	1036.0	45.6	45.6	63.0	84.0	3.2	2.9	43.1	21.0	2.8	2.5	0.079
131	02-Jul-99	725.2	178.2	180.3	85.0	1098.2	64.2	35.2	62.6	84.0	3.9	2.7	47.3	22.7	2.7	2.7	0.086
132	03-Jul-99	No Test															
133	04-Jul-99	No Test (Stirrer on SET2 failed)															
134	05-Jul-99	No Test (Dregs of last sewage) - New Sewage fed today															
BATCH 10 Averages:		***799.4***	***175.7***	***177.8***	***103.5***	***1229.8***	***62.2***	***51.7***	***63.4***	***90.4***	***7.9***	***7.2***	***48.1***	***22.4***	***10.0***	***6.0***	***0.079***
135	06-Jul-99	844.6	167.3	108.1	116.3	1652.4	67.3	55.1	96.9	110.6	5.0	4.1	77.3	32.8	10.1	2.2	0.115
136	07-Jul-99	1093.4	195.8	126.5	134.6	1836.0	85.7	77.5	90.0	112.0	4.8	3.1	74.2	31.9	8.3	2.2	0.082
137	08-Jul-99	738.5	159.1	95.9	120.4	1897.2	87.7	51.0	88.1	121.8	2.8	2.1	72.8	31.1	7.4	2.1	0.119
138	09-Jul-99	705.8	159.1	181.6	222.4	1897.2	100.0	59.2	85.1	120.4	4.2	2.2	76.2	30.8	8.0	2.1	0.121
139	10-Jul-99	701.8	146.9	208.1	118.3	1876.8	85.7	61.2	83.4	121.8	4.8	3.8	70.8	31.4	8.1	2.2	0.119
140	11-Jul-99	783.4	187.7	126.5	89.8	1958.4	69.4	61.2	86.9	117.6	4.3	4.1	76.4	28.0	5.9	2.5	0.111
141	12-Jul-99	No Test															
142	13-Jul-99	760.7	193.3	117.2	80.2	2035.4	63.7	55.5	82.2	116.2	4.5	3.2	71.4	28.3	7.6	2.2	0.108
143	14-Jul-99	818.3	176.8	129.5	80.2	1829.8	96.6	63.7	93.2	126.0	5.9	2.8	73.6	32.2	8.1	2.2	0.114
144	15-Jul-99	801.8	135.7	121.3	47.3	1788.7	92.5	51.4	93.1	120.4	7.0	3.6	73.6	33.9	19.5	2.2	0.116
145	16-Jul-99	Cleaned Unit															
146	17-Jul-99	No Test (Recouperate)															
147	18-Jul-99	666.1	172.7	152.1	90.5	1973.8	69.9	69.9	89.7	116.2	4.5	3.9	69.7	31.1	19.3	2.5	0.135
148	19-Jul-99	830.6	139.8	127.5	65.8	1809.3	78.1	41.1	89.2	114.8	6.2	4.2	72.0	31.5	14.1	3.2	0.107
149	20-Jul-99	No Test (Steering Commitee Meeting)															
150	21-Jul-99	741.9	161.3	181.4	76.6	1774.1	84.7	36.3	82.2	117.6	6.3	4.2	69.4	33.7	6.2	2.8	0.111
151	22-Jul-99	693.5	169.3	225.8	88.7	1572.5	48.4	28.2	83.2	110.6	2.9	2.9	68.3	31.2	4.8	2.1	0.120
152	23-Jul-99	No Test (New Sewage Fed Today)															
BATCH 11 Averages:		***783.1***	***166.5***	***146.3***	***102.4***	***1838.6***	***79.2***	***54.7***	***87.9***	***117.4***	***4.9***	***3.4***	***72.8***	***31.4***	***9.8***	***2.4***	***0.114***
153	24-Jul-99	No Test (New Sewage)															
154	25-Jul-99	No Test (Electricity off)															
155	26-Jul-99	834.6	197.6	106.8	62.5	1471.7	46.4	30.2	88.5	107.8	3.5	2.9	70.6	29.8	2.2	2.1	0.106
156	27-Jul-99	842.7	221.8	135.1	86.7	1471.7	110.9	54.4	88.8	106.4	4.6	3.9	72.2	28.1	2.8	2.8	0.105
157	28-Jul-99	778.2	131.6	111.0	78.1	1480.3	74.0	49.3	82.0	121.8	4.1	3.8	62.2	25.8	1.8	2.1	0.105
158	29-Jul-99	No Test (Nitrifier blocked up & overflowed violently)															
159	30-Jul-99	657.9	160.4	84.3	80.2	1829.8	47.3	35.0	79.8	110.6	3.5	2.7	63.8	27.4	5.6	2.2	0.121

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
160	31-Jul-99	No Test															
161	01-Aug-99	No Test - Air off for 24 hours, entire system anoxic/anaerobic															
162	02-Aug-99	760.7	172.7	123.4	61.7	1850.4	69.9	41.1	84.6	124.6	16.2	15.4	71.4	30.7	4.3	15.4	0.111
163	03-Aug-99	789.5	172.7	102.8	57.6	1685.9	49.3	49.3	86.2	124.6	4.6	4.5	70.0	30.4	2.8	2.4	0.109
164	04-Aug-99	No Test - Power cut, DO boxes reset, no air															
165	05-Aug-99	729.1	122.9	114.7	69.6	1761.3	57.3	36.9	84.8	126.0	2.9	2.9	64.7	31.2	3.1	2.9	0.116
166	06-Aug-99	720.9	172.0	131.1	65.5	1884.2	45.1	28.7	89.0	119.0	6.4	3.1	69.2	31.8	3.4	3.8	0.124
BATCH 12 Averages:		***764.2***	***169.0***	***113.6***	***70.2***	***1679.4***	***62.5***	***40.6***	***85.5***	***117.6***	***5.7***	***4.9***	***68.0***	***29.4***	***3.3***	***4.2***	***0.112***
167	07-Aug-99	No Test - New Sewage															
168	08-Aug-99	725.0	196.6	94.2	41.0	1802.2	57.3	32.8	38.8	116.2	3.2	2.8	26.6	11.8	2.0	1.7	0.053
169	09-Aug-99	634.9	118.8	116.7	75.8	1986.6	55.3	51.2	80.1	123.2	3.5	2.9	65.2	29.3	2.7	2.5	0.126
170	10-Aug-99	774.1	155.6	118.8	57.3	2007.0	49.2	20.5	82.6	112.0	4.1	2.9	66.4	30.7	2.4	2.5	0.107
171	11-Aug-99	950.3	159.7	120.8	67.6	1658.9	59.4	51.2	85.0	117.6	4.3	4.1	70.3	31.1	2.4	2.2	0.089
172	12-Aug-99	No Test - Cleaned Unit															
173	13-Aug-99	809.4	204.4	163.5	102.2	1880.5	85.8	77.7	80.6	102.2	4.2	4.1	69.4	29.8	2.9	2.4	0.100
174	14-Aug-99	No Test															
175	15-Aug-99	633.6	85.8	120.6	92.0	1410.4	42.9	42.9	67.6	107.8	4.3	3.8	56.6	22.5	3.2	3.2	0.107
176	16-Aug-99	919.8	163.5	110.4	53.1	1614.8	40.9	40.9	80.1	113.4	4.6	4.2	73.4	30.2	3.2	3.2	0.087
177	17-Aug-99	899.4	130.8	139.0	61.3	1676.1	45.0	40.9	90.3	106.4	4.5	3.8	78.1	33.5	3.4	3.2	0.100
178	18-Aug-99	784.9	151.3	132.9	51.1	1614.8	38.8	26.6	89.6	106.4	4.3	3.9	73.6	30.9	2.8	2.8	0.114
179	19-Aug-99	809.4	184.0	161.5	63.4	1778.3	47.0	47.0	83.6	105.0	5.0	4.6	69.2	32.8	3.1	3.1	0.103
180	20-Aug-99	723.6	184.0	153.3	67.5	1696.5	55.2	47.0	87.4	105.0	4.8	3.6	75.3	31.2	3.8	3.6	0.121
181	21-Aug-99	No Test															
182	22-Aug-99	731.8	212.6	143.1	65.4	1717.0	65.4	53.1	89.5	103.6	4.9	4.1	75.0	32.1	2.9	2.9	0.122
183	23-Aug-99	795.2	168.9	146.3	76.2	1833.4	63.9	43.3	89.6	105.0	4.8	4.1	73.9	31.4	2.9	2.8	0.113
184	24-Aug-99	778.7	144.2	154.5	84.5	1792.2	88.6	51.5	88.1	106.4	4.3	3.9	74.5	31.6	2.7	2.9	0.113
185	25-Aug-99	770.4	98.9	144.2	74.2	1689.2	65.9	45.3	86.5	100.8	5.2	4.8	73.4	31.2	2.9	3.1	0.112
186	26-Aug-99	754.0	107.1	131.8	61.8	1771.6	65.9	49.4	88.9	103.6	4.9	3.5	73.6	31.4	2.7	2.4	0.118
BATCH 13 Averages:		***780.9***	***154.1***	***134.5***	***68.4***	***1745.6***	***57.9***	***45.1***	***81.8***	***108.4***	***4.4***	***3.8***	***68.4***	***29.5***	***2.9***	***2.8***	***0.105***
187	27-Aug-99	No Test (New Sewage)															
188	28-Aug-99	No Test (New Sewage)															
189	29-Aug-99	676.5	169.7	140.5	43.7	1713.9	43.7	31.3	79.8	109.2	4.5	3.5	64.4	27.3	2.1	2.1	0.118
190	30-Aug-99	845.4	181.3	164.8	49.4	1442.0	37.1	33.0	84.3	103.6	3.8	3.8	59.1	28.0	3.6	3.2	0.100
191	31-Aug-99	770.4	201.9	138.0	68.0	1627.4	35.0	35.0	81.6	103.6	4.1	3.1	59.6	26.7	2.7	2.8	0.106

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
192	01-Sep-99	774.6	147.7	143.6	41.0	1641.6	41.0	41.0	82.2	106.4	4.9	4.2	63.6	27.6	3.2	2.9	0.106
193	02-Sep-99	767.4	176.5	137.5	47.2	1703.2	39.0	39.0	81.5	103.6	3.9	3.4	58.0	27.6	3.1	2.8	0.106
194	03-Sep-99	710.0	143.6	125.2	55.4	1703.2	47.2	30.8	80.4	107.8	5.2	4.3	59.6	27.6	3.5	2.9	0.113
195	04-Sep-99	No Test (Changed Main ANO to 9l and Main AE to 4l)															
196	05-Sep-99	632.0	160.1	108.8	30.8	1580.0	43.1	39.0	76.6	84.0	4.5	3.4	53.2	28.0	3.2	3.2	0.121
197	06-Sep-99	738.7	164.2	143.6	45.1	1436.4	49.2	36.9	82.0	96.6	4.5	3.8	64.4	27.4	2.9	3.6	0.111
198	07-Sep-99	689.5	156.0	139.5	36.9	1436.4	32.8	24.6	77.8	89.6	4.2	3.8	55.7	27.2	2.8	3.2	0.113
199	08-Sep-99	718.2	168.3	141.6	30.8	1498.0	26.7	26.7	79.4	88.2	4.3	3.4	64.4	28.0	3.1	3.1	0.111
200	09-Sep-99	726.4	151.3	149.2	38.8	1369.5	30.7	30.7	80.6	92.4	5.0	3.2	62.2	28.0	3.1	3.1	0.111
201	10-Sep-99	535.5	139.0	155.3	65.4	1471.7	45.0	40.9	78.3	85.4	4.1	3.8	65.2	27.9	3.2	3.1	0.146
202	11-Sep-99	No Test															
203	12-Sep-99	No Test - Dregs of sewage batch															
BATCH 14 Averages:		***715.4***	***163.3***	***140.6***	***46.1***	***1551.9***	***39.2***	***34.1***	***80.4***	***97.5***	***4.4***	***3.6***	***60.8***	***27.6***	***3.0***	***3.0***	***0.113***
204	13-Sep-99	No Test - New Sewage															
205	14-Sep-99	No Test - New Sewage															
206	15-Sep-99	No Test - AN overflowed															
207	16-Sep-99	723.6	171.7	155.3	61.3	1185.5	53.1	40.9	91.3	98.0	8.3	8.1	72.8	30.2	4.5	6.6	0.126
208	17-Sep-99	No Test															
209	18-Sep-99	No Test															
210	19-Sep-99	744.0	208.5	153.3	55.2	1328.6	63.4	51.1	94.8	96.6	4.9	4.2	75.3	34.6	2.9	4.2	0.127
211	20-Sep-99	760.4	212.6	159.4	65.4	1471.7	57.2	53.1	94.1	98.0	5.2	4.2	74.5	33.9	3.2	3.5	0.124
212	21-Sep-99	735.8	192.1	161.5	55.2	1573.9	51.1	42.9	93.7	99.4	4.9	3.8	77.3	34.4	3.6	3.6	0.127
213	22-Sep-99	674.5	192.9	137.5	47.2	1456.9	39.0	39.0	86.2	95.2	5.0	4.2	75.6	34.7	2.8	3.4	0.128
214	23-Sep-99	No Test - Electricity off															
215	24-Sep-99	No Test															
216	25-Sep-99	No Test															
BATCH 15 Averages:		***727.7***	***195.6***	***153.4***	***56.9***	***1403.3***	***52.8***	***45.4***	***92.0***	***97.4***	***5.7***	***4.9***	***75.1***	***33.6***	***3.4***	***4.3***	***0.126***
217	26-Sep-99	New Sewage															
218	27-Sep-99	No Test - New Batch															
219	28-Sep-99	816.7	209.3	199.0	63.6	1662.1	47.2	47.2	87.4	119.0	5.3	4.8	68.6	35.0	3.6	3.8	0.107
220	29-Sep-99	829.0	229.8	266.8	49.2	1682.6	57.5	45.1	94.4	120.4	5.0	4.8	74.5	35.0	4.3	4.8	0.114
221	30-Sep-99	730.5	188.8	147.7	32.8	1887.8	32.8	28.7	86.0	121.8	5.0	4.3	69.7	31.1	3.2	3.4	0.118
222	01-Oct-99	738.7	192.9	125.2	43.1	1990.4	43.1	34.9	84.6	120.4	4.9	4.2	68.6	31.2	3.4	3.4	0.114
223	02-Oct-99	No Test															

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
224	03-Oct-99	741.4	204.8	131.1	45.1	2048.0	45.1	28.7	83.9	126.0	5.5	5.2	69.7	31.4	3.5	3.4	0.113
225	04-Oct-99	745.5	196.6	147.5	53.2	2252.8	53.2	41.0	85.5	134.4	5.6	5.0	66.4	31.6	3.4	3.4	0.115
226	05-Oct-99	729.1	188.4	127.0	32.8	2170.9	36.9	16.4	83.6	137.2	5.0	4.3	65.0	32.5	3.8	3.6	0.115
227	06-Oct-99	766.0	176.1	145.4	43.0	2109.4	34.8	34.8	82.7	130.2	5.5	4.8	69.2	32.5	3.8	3.4	0.108
228	07-Oct-99	700.4	184.3	141.3	51.2	2109.4	43.0	38.9	80.1	120.4	4.3	3.4	63.0	32.2	3.1	3.4	0.114
229	08-Oct-99	790.5	188.4	147.5	57.3	2089.0	32.8	32.8	84.1	137.2	4.8	3.9	65.5	31.9	3.1	3.1	0.106
230	09-Oct-99	No Test															
231	10-Oct-99	SET 2 overflowed - No Test															
BATCH 16 Averages:		***758.8***	***195.9***	***157.8***	***47.1***	***2000.3***	***42.6***	***34.8***	***85.2***	***126.7***	***5.1***	***4.5***	***68.0***	***32.4***	***3.5***	***3.5***	***0.112***
232	11-Oct-99	New Sewage															
233	12-Oct-99	No Test - New Batch															
234	13-Oct-99	665.6	167.5	110.2	92.6	2336.2	48.5	26.4	73.1	152.6	4.8	3.6	58.0	27.3	3.1	3.2	0.110
235	14-Oct-99	736.1	154.3	138.9	55.1	2270.1	50.7	50.7	63.4	128.8	4.8	3.5	48.7	24.8	3.2	3.5	0.086
236	15-Oct-99	692.1	158.7	141.1	48.5	2292.2	52.9	30.9	68.6	137.2	4.8	3.6	52.6	24.2	2.7	2.5	0.099
237	16-Oct-99	No Test															
238	17-Oct-99	670.0	163.1	138.9	59.5	2358.3	50.7	41.9	67.3	142.8	4.5	3.8	49.8	24.6	3.4	3.2	0.101
239	18-Oct-99	No Test (Stephanie Batch Test - 3l from AN)															
240	19-Oct-99	636.5	146.9	118.3	44.9	1713.6	44.9	44.9	65.1	130.2	5.0	4.9	52.6	26.0	3.4	3.6	0.102
241	20-Oct-99	681.4	191.8	148.9	67.3	1897.2	67.3	51.0	62.4	112.0	4.8	3.4	47.6	24.5	2.5	2.8	0.092
242	21-Oct-99	632.4	163.2	126.5	53.0	1795.2	49.0	40.8	64.8	123.2	4.6	3.8	53.8	24.2	3.4	3.8	0.102
243	22-Oct-99	644.6	159.1	138.7	42.8	1938.0	38.8	38.8	70.3	142.8	5.3	5.0	58.2	27.7	3.4	3.8	0.109
244	23-Oct-99	No Test															
245	24-Oct-99	620.2	134.6	157.1	51.0	1815.6	42.8	38.8	67.3	144.2	5.2	4.8	52.1	27.0	3.2	3.9	0.109
BATCH 17 Averages:		***664.3***	***159.9***	***135.4***	***57.2***	***2046.3***	***49.5***	***40.5***	***66.9***	***134.9***	***4.9***	***4.0***	***52.6***	***25.6***	***3.1***	***3.4***	***0.101***
246	25-Oct-99	New Sewage Fed Today, Cleaned Unit, 3l AN for Stephanie															
247	26-Oct-99	No Test - New Batch															
248	27-Oct-99	No Test - New Batch															
249	28-Oct-99	763.0	191.8	136.7	46.9	1570.8	34.7	26.5	69.0	109.2	4.6	3.6	50.4	25.1	3.8	3.5	0.090
250	29-Oct-99	789.5	212.2	151.0	65.3	1632.0	44.9	36.7	70.6	112.0	4.3	3.4	54.0	24.8	2.9	2.9	0.089
251	30-Oct-99	No Test															
252	31-Oct-99	746.6	199.9	148.9	51.0	1611.6	42.8	38.8	68.5	116.2	4.9	3.9	51.8	24.9	3.2	3.5	0.092
253	01-Nov-99	771.1	224.4	193.8	67.3	1570.8	59.2	42.8	69.7	120.4	4.5	3.9	55.2	24.8	3.1	3.5	0.090
254	02-Nov-99	795.6	216.2	153.0	67.3	2182.8	46.9	46.9	67.6	140.0	5.3	4.6	51.8	24.9	3.4	3.6	0.085
255	03-Nov-99	824.2	204.0	130.6	53.0	2325.6	49.0	32.6	68.5	137.2	4.3	3.8	52.1	25.6	3.4	3.2	0.083

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
256	04-Nov-99	733.2	184.3	149.5	43.0	2109.4	38.9	30.7	70.0	147.0	5.2	3.9	56.0	27.3	3.5	3.6	0.095
257	05-Nov-99	No Test - Nitrifier Overflowed															
258	06-Nov-99	No Test															
259	07-Nov-99	639.0	172.0	155.6	36.9	2293.8	36.9	28.7	67.8	151.2	4.5	4.1	52.6	25.3	3.2	3.8	0.106
BATCH 18 Averages:		***757.8***	***200.6***	***152.4***	***53.8***	***1912.1***	***44.2***	***35.5***	***69.0***	***129.2***	***4.7***	***3.9***	***53.0***	***25.3***	***3.3***	***3.5***	***0.091***
260	08-Nov-99	New Sewage Fed Today															
261	09-Nov-99	No Test - New Batch															
262	10-Nov-99	No Test - New Batch															
263	11-Nov-99	693.6	201.1	141.6	47.2	1990.4	39.0	39.0	84.3	141.4	5.3	4.3	64.1	33.3	3.5	3.2	0.122
264	12-Nov-99	656.6	213.4	139.5	65.7	2216.2	57.5	57.5	81.8	140.0	5.2	4.3	66.1	32.2	3.4	3.4	0.125
265	13-Nov-99	No Test															
266	14-Nov-99	640.8	194.7	133.8	60.8	2230.8	73.0	69.0	83.0	144.2	5.3	5.0	64.4	32.9	3.8	4.2	0.130
267	15-Nov-99	713.9	198.7	131.8	62.9	1926.6	42.6	42.6	88.6	137.2	5.2	4.3	72.8	35.0	3.4	3.5	0.124
268	16-Nov-99	No Test - Stephanie Batch Test Yesterday (3l AN)															
269	17-Nov-99	705.7	210.9	117.6	69.0	2271.4	44.6	36.5	89.2	154.0	5.6	4.9	75.0	35.4	3.5	3.8	0.126
270	18-Nov-99	709.8	202.8	113.6	69.0	2109.1	48.7	36.5	86.8	148.4	5.5	4.5	72.2	35.3	3.2	3.8	0.122
271	19-Nov-99	674.2	198.5	128.2	70.3	2109.4	37.2	37.2	87.1	144.2	5.2	4.6	72.5	34.4	3.2	3.2	0.129
BATCH 19 Averages:		***684.9***	***202.9***	***129.5***	***63.5***	***2122.0***	***48.9***	***45.5***	***85.8***	***144.2***	***5.3***	***4.6***	***69.6***	***34.1***	***3.4***	***3.6***	***0.125***
272	20-Nov-99	No Test - New Batch															
273	21-Nov-99	756.9	153.0	130.3	43.4	1840.5	31.0	31.0	70.3	137.2	5.0	4.2	54.0	25.5	3.2	3.8	0.093
274	22-Nov-99	794.1	182.0	153.0	57.9	2440.2	45.5	33.1	70.0	147.0	4.9	4.2	53.5	25.5	3.4	3.2	0.088
275	23-Nov-99	756.9	169.6	113.7	60.0	1923.2	35.2	26.9	70.6	140.0	4.9	4.1	54.9	25.6	3.2	3.8	0.093
276	24-Nov-99	773.4	157.2	128.2	49.6	2192.1	45.5	33.1	72.0	141.4	4.6	4.2	54.3	25.8	3.2	3.8	0.093
277	25-Nov-99	823.1	194.4	134.4	60.0	2378.2	47.6	43.4	71.3	147.0	4.5	4.1	53.2	25.6	3.5	3.9	0.087
278	26-Nov-99	No Test - Exam															
279	27-Nov-99	No Test - Exam															
280	28-Nov-99	752.8	177.8	146.8	60.0	2212.8	35.2	35.2	70.8	155.4	4.6	4.1	53.8	26.6	3.1	3.6	0.094
281	29-Nov-99	No Test - Stephanie Batch Test Yesterday (3l AN)															
282	30-Nov-99	752.2	196.2	143.1	45.0	2411.9	53.1	40.9	70.8	156.8	4.2	3.6	54.6	26.2	3.2	3.4	0.094
283	01-Dec-99	789.0	192.1	141.0	42.9	2391.5	55.2	42.9	70.3	156.8	5.0	4.5	53.2	26.2	3.9	4.1	0.089
284	02-Dec-99	650.0	163.5	139.0	45.0	2411.9	45.0	32.7	68.5	140.0	4.9	4.5	54.0	25.9	3.4	3.9	0.105
BATCH 20 Averages:		***760.9***	***176.2***	***136.6***	***51.5***	***2244.7***	***43.7***	***35.5***	***70.5***	***146.8***	***4.7***	***4.2***	***53.9***	***25.9***	***3.3***	***3.7***	***0.093***
285	03-Dec-99	No Test - New Sewage Fed Yesterday															
286	04-Dec-99	No Test - New Batch															

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
287	05-Dec-99	731.8	200.3	145.1	59.3	2228.0	51.1	51.1	67.5	145.6	4.5	4.2	55.4	24.5	3.6	4.2	0.092
288	06-Dec-99	739.9	184.0	128.8	51.1	2268.8	42.9	34.7	66.1	140.0	4.5	3.9	52.4	25.2	3.4	3.6	0.089
289	07-Dec-99	723.6	171.7	130.8	53.1	2084.9	36.8	36.8	67.6	121.8	4.6	4.2	52.9	25.5	3.2	3.8	0.093
290	08-Dec-99	699.0	173.7	115.8	57.9	2398.9	45.5	33.1	66.9	137.2	5.0	4.6	53.2	26.3	3.4	4.2	0.096
291	09-Dec-99	847.9	215.1	140.6	66.2	2440.2	49.6	49.6	66.1	121.8	4.2	3.9	47.6	25.1	3.4	3.5	0.078
292	10-Dec-99	No Test - Cleaned Unit Yesterday															
293	11-Dec-99	No Test															
294	12-Dec-99	736.2	194.4	142.7	64.1	2419.6	47.6	43.4	66.6	149.8	4.8	4.3	49.8	26.5	3.5	3.8	0.091
295	13-Dec-99	765.2	244.0	122.0	64.1	2460.9	43.4	35.2	70.0	162.4	5.0	4.5	52.6	26.3	3.6	3.9	0.091
296	14-Dec-99	No Test - New Sewage Fed Today															
BATCH 21 Averages:		***749.1***	***197.6***	***132.3***	***59.4***	***2328.8***	***45.3***	***40.6***	***67.3***	***139.8***	***4.7***	***4.2***	***52.0***	***25.6***	***3.4***	***3.9***	***0.090***
297	15-Dec-99	No Test - New Sewage															
298	16-Dec-99	No Test - New Sewage															
299	17-Dec-99	719.7	173.7	107.5	70.3	2564.3	29.0	24.8	80.9	173.6	4.8	4.3	67.8	32.3	3.2	3.4	0.112
300	18-Dec-99	No Test															
301	19-Dec-99	727.9	157.2	136.5	62.0	2068.0	29.0	29.0	80.8	152.6	5.2	4.8	67.5	31.8	3.8	3.9	0.111
302	20-Dec-99	761.0	165.4	128.2	91.0	2150.7	41.4	37.2	79.8	142.8	4.3	3.9	61.6	30.8	3.5	3.9	0.105
303	21-Dec-99	719.7	186.1	130.3	55.8	2295.5	39.3	31.0	84.0	144.2	5.2	4.8	68.9	30.5	3.5	3.8	0.117
304	22-Dec-99	732.1	194.4	146.8	64.1	2212.8	47.6	43.4	80.2	145.6	4.2	3.9	64.7	31.2	3.4	3.5	0.110
305	23-Dec-99	727.9	173.7	206.8	45.5	1985.3	45.5	37.2	80.1	145.6	4.9	4.2	64.7	31.5	3.5	3.5	0.110
306	24-Dec-99	No Test															
307	25-Dec-99	No Test															
308	26-Dec-99	711.4	206.8	144.8	70.3	1861.2	57.9	53.8	80.1	126.0	5.3	4.9	66.6	32.3	4.1	4.2	0.113
309	27-Dec-99	707.3	202.7	138.6	51.7	1964.6	43.4	35.2	81.5	134.4	4.1	3.9	66.4	32.1	3.9	3.5	0.115
310	28-Dec-99	699.0	140.6	132.4	57.9	1985.3	37.2	33.1	79.7	137.2	4.6	3.5	59.6	31.2	3.4	3.4	0.114
311	29-Dec-99	674.2	215.1	153.0	53.8	2316.2	57.9	49.6	82.0	134.4	4.8	4.2	68.0	32.5	3.6	4.1	0.122
BATCH 22 Averages:		***718.0***	***181.6***	***142.5***	***62.2***	***2140.4***	***42.8***	***37.4***	***80.9***	***143.6***	***4.7***	***4.2***	***65.6***	***31.6***	***3.6***	***3.7***	***0.113***
312	30-Dec-99	No Test - New Sewage Fed Today															
313	31-Dec-99	No Test - New Sewage															
314	01-Jan-00	No Test - New Sewage															
315	02-Jan-00	682.4	182.0	111.7	57.9	2026.6	41.4	37.2	114.0	144.2	6.0	5.9	97.2	47.0	3.4	3.5	0.167
316	03-Jan-00	761.0	190.3	111.7	57.9	1654.4	45.5	37.2	111.7	140.0	5.9	4.6	94.4	44.5	3.4	4.1	0.147
317	04-Jan-00	752.8	182.0	144.8	53.8	1778.5	57.9	45.5	80.4	126.0	5.0	4.2	66.1	32.3	3.4	3.4	0.107
318	05-Jan-00	754.8	195.8	126.5	53.0	1672.8	53.0	40.8	85.0	127.4	5.2	4.2	69.4	31.5	3.2	3.6	0.113

		mgCOD/l							mgN/l									
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
319	06-Jan-00	722.2	146.9	134.6	53.0	1468.8	40.8	28.6	83.3	126.0	5.0	3.9	64.4	30.9	3.4	3.9	0.115
320	07-Jan-00	722.2	146.9	102.0	40.8	1550.4	28.6	28.6	84.4	128.8	5.0	4.8	67.8	32.5	3.5	3.9	0.117
321	08-Jan-00	No Test															
322	09-Jan-00	No Test															
323	10-Jan-00	722.2	167.3	148.9	46.9	1448.4	38.8	38.8	84.7	121.8	5.2	4.6	67.5	31.2	3.2	3.6	0.117
324	11-Jan-00	763.0	187.7	146.9	32.6	1550.4	53.0	36.7	75.9	119.0	5.2	4.6	59.6	29.4	3.9	4.2	0.099
325	12-Jan-00	718.1	159.1	136.7	51.0	1448.4	30.6	26.5	79.8	113.4	5.3	4.8	65.8	31.2	3.4	4.2	0.111
326	13-Jan-00	734.4	146.9	130.6	44.9	1468.8	24.5	24.5	73.6	113.4	4.1	3.8	63.8	30.8	3.4	3.8	0.100
327	14-Jan-00	612.0	204.0	122.4	77.5	2366.4	40.8	40.8	80.1	145.6	5.2	4.5	64.7	29.8	3.5	3.8	0.131
BATCH 23 Averages:		***722.3***	***173.5***	***128.8***	***51.8***	***1675.8***	***41.3***	***35.0***	***86.6***	***127.8***	***5.2***	***4.5***	***71.0***	***33.8***	***3.4***	***3.8***	***0.120***
328	15-Jan-00	No Test - New Sewage Fed Yesterday															
329	16-Jan-00	542.8	102.8	92.5	26.7	2282.2	39.1	39.1	68.9	142.8	4.6	4.2	56.0	26.2	3.5	3.8	0.127
330	17-Jan-00	534.6	156.3	119.2	61.7	2302.7	32.9	32.9	66.5	142.8	4.6	3.8	53.8	24.5	3.5	3.8	0.124
331	18-Jan-00	764.8	197.4	115.1	53.5	2179.4	45.2	37.0	94.5	159.6	5.3	4.8	78.4	37.2	3.5	4.2	0.124
332	19-Jan-00	814.2	189.2	152.1	61.7	2097.1	49.3	49.3	96.7	151.2	5.6	4.5	76.4	35.8	3.2	4.3	0.119
333	20-Jan-00	752.5	222.0	127.5	65.8	2138.2	61.7	49.3	96.5	156.8	5.3	4.5	77.6	36.4	3.8	4.1	0.128
334	21-Jan-00	719.6	164.5	102.8	74.0	2138.2	57.6	41.1	95.5	147.0	5.5	4.8	77.8	36.5	3.5	4.2	0.133
335	22-Jan-00	No Test															
336	23-Jan-00	No Test - Overflow from SET 2 fell off - emptied ANO into tray															
337	24-Jan-00	740.3	186.1	109.6	47.6	2088.7	47.6	31.0	92.4	147.0	6.2	5.2	77.8	36.5	3.2	4.8	0.125
338	25-Jan-00	802.4	173.7	124.1	66.2	2192.1	49.6	45.5	94.6	149.8	5.9	5.3	80.1	38.9	3.6	4.5	0.118
339	26-Jan-00	752.8	198.5	62.0	41.4	1819.8	41.4	33.1	95.8	138.6	6.6	5.5	79.8	35.7	4.2	4.8	0.127
340	27-Jan-00	Cleaned Unit - No Test															
341	28-Jan-00	New Sewage Fed Today															
BATCH 24 Averages:		***713.8***	***176.7***	***111.7***	***55.4***	***2137.6***	***47.1***	***39.8***	***89.0***	***148.4***	***5.5***	***4.7***	***73.1***	***34.2***	***3.6***	***4.3***	***0.125***
342	29-Jan-00	No Test - New Sewage															
343	30-Jan-00	No Test - New Sewage															
344	31-Jan-00	678.3	285.4	113.7	43.4	2088.7	39.3	18.6	61.2	148.4	5.0	4.6	48.4	22.5	3.4	3.6	0.090
345	01-Feb-00	818.9	198.5	111.7	37.2	2109.4	37.2	33.1	66.2	142.8	5.6	4.2	53.2	24.2	3.4	4.2	0.081
346	02-Feb-00	No Test															
347	03-Feb-00	754.8	277.4	114.2	53.0	2203.2	44.9	44.9	67.2	145.6	5.3	4.6	55.2	25.9	3.9	4.6	0.089
348	04-Feb-00	754.8	261.1	114.2	32.6	1917.6	20.4	20.4	67.2	154.0	4.2	4.2	50.7	23.5	3.5	3.6	0.089
349	05-Feb-00	No Test															
350	06-Feb-00	742.6	171.4	122.4	53.0	2448.0	53.0	40.8	66.1	154.0	5.2	4.6	52.6	24.8	3.4	3.6	0.089

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
351	07-Feb-00	783.4	187.7	118.3	53.0	2488.8	61.2	49.0	67.8	163.8	5.6	4.6	53.2	24.5	3.5	3.9	0.086
352	08-Feb-00	780.3	223.5	132.1	54.9	2661.9	54.9	46.7	61.6	149.8	5.2	4.3	51.2	23.2	3.4	3.6	0.079
353	09-Feb-00	747.8	195.1	130.0	52.8	2479.0	56.9	56.9	65.1	158.2	5.0	3.8	53.8	24.4	3.1	3.5	0.087
354	10-Feb-00	776.2	203.2	134.1	52.8	2397.8	48.8	48.8	65.7	159.6	4.8	4.1	50.4	23.8	3.6	3.5	0.085
355	11-Feb-00	New Sewage Fed Today															
BATCH 25 Averages:		***759.7***	***222.6***	***121.2***	***48.1***	***2310.5***	***46.3***	***39.9***	***65.3***	***152.9***	***5.1***	***4.3***	***52.1***	***24.1***	***3.5***	***3.8***	***0.086***
356	12-Feb-00	No Test - New Sewage															
357	13-Feb-00	No Test - New Sewage															
358	14-Feb-00	613.7	126.0	107.7	50.8	2377.4	38.6	26.4	71.0	168.0	5.6	4.5	59.4	31.8	3.4	3.9	0.116
359	15-Feb-00	597.4	186.9	121.9	52.8	2397.8	40.6	32.5	74.9	172.2	5.2	4.5	61.0	29.5	3.4	3.8	0.125
360	16-Feb-00	690.9	138.2	121.9	56.9	2275.8	48.8	48.8	75.6	163.8	5.0	3.9	61.3	28.6	3.4	3.4	0.109
361	17-Feb-00	823.3	188.4	151.6	41.0	2170.9	41.0	41.0	90.4	159.6	5.0	4.5	70.6	33.6	3.4	3.9	0.110
362	18-Feb-00	No Test - Stephanie Batch Test Yesterday (3l AN)															
363	19-Feb-00	No Test - Nit/SET2 blocked up															
364	20-Feb-00	749.6	184.3	104.4	26.6	2396.2	43.0	38.9	83.2	165.2	4.9	4.5	64.4	30.5	3.4	4.1	0.111
365	21-Feb-00	790.5	204.8	135.2	36.9	2621.4	41.0	32.8	92.8	182.0	4.6	4.2	73.6	32.5	3.2	3.2	0.117
366	22-Feb-00	737.3	180.2	131.1	32.8	2703.4	41.0	41.0	81.9	182.0	4.8	4.1	66.1	31.4	3.6	3.8	0.111
367	23-Feb-00	749.6	176.1	161.8	47.1	2560.0	47.1	38.9	82.6	177.8	3.9	3.6	64.7	30.9	3.2	3.4	0.110
368	24-Feb-00	626.7	188.4	147.5	41.0	2826.2	47.1	36.9	79.8	180.6	4.8	4.1	63.6	29.5	2.9	3.1	0.127
BATCH 26 Averages:		***708.8***	***174.8***	***131.4***	***42.9***	***2481.0***	***43.1***	***37.5***	***81.4***	***172.4***	***4.9***	***4.2***	***65.0***	***30.9***	***3.3***	***3.6***	***0.115***
369	25-Feb-00	New Sewage Fed Today															
370	26-Feb-00	No Test - New Sewage															
371	27-Feb-00	720.9	196.6	127.0	57.3	2375.7	57.3	36.9	83.6	130.2	4.8	4.2	69.2	25.5	2.9	3.8	0.116
372	28-Feb-00	585.7	180.2	131.1	61.4	2416.6	49.2	45.1	62.7	140.0	4.6	3.9	49.8	26.6	2.8	3.2	0.107
373	29-Feb-00	745.5	192.5	129.0	43.0	3051.5	43.0	30.7	74.9	191.8	4.2	3.9	58.8	27.3	3.2	3.6	0.100
374	01-Mar-00	655.4	208.9	124.9	55.3	2437.1	51.2	47.1	70.1	165.2	5.2	4.5	61.3	26.0	3.4	4.1	0.107
375	02-Mar-00	756.1	199.7	125.3	44.6	2782.4	40.4	36.1	68.3	166.6	4.8	3.6	58.8	26.6	3.2	3.4	0.090
376	03-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)															
377	04-Mar-00	No Test															
378	05-Mar-00	756.1	178.4	131.7	55.2	3101.0	51.0	29.7	72.5	168.0	4.2	3.8	59.6	26.0	3.5	3.4	0.096
379	06-Mar-00	773.1	199.7	138.1	44.6	3037.3	44.6	31.9	75.7	173.6	4.3	3.8	62.2	26.6	2.8	3.2	0.098
380	07-Mar-00	696.7	208.2	129.6	48.9	2527.6	53.1	36.1	72.5	155.4	3.9	3.5	57.7	26.6	2.8	2.9	0.104
381	08-Mar-00	No Test (No Dist. Water)															
382	09-Mar-00	New Sewage Fed Today															

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
BATCH 27 Averages:		***711.2***	***195.5***	***129.6***	***51.3***	***2716.2***	***48.7***	***36.7***	***72.6***	***161.4***	***4.5***	***3.9***	***59.7***	***26.4***	***3.1***	***3.4***	***0.102***
383	10-Mar-00	No Test - New Sewage															
384	11-Mar-00	No Test - New Sewage															
385	12-Mar-00	685.4	151.8	117.0	51.3	2072.5	55.4	32.8	90.6	137.2	4.3	3.6	72.8	32.8	2.8	3.2	0.132
386	13-Mar-00	738.7	139.5	127.2	36.9	2544.5	41.0	41.0	88.2	137.2	4.8	3.6	72.0	32.9	2.9	3.2	0.119
387	14-Mar-00	742.8	123.1	131.3	69.8	2770.2	69.8	61.6	88.5	128.8	4.3	3.8	72.8	32.5	3.1	3.4	0.119
388	15-Mar-00	775.7	176.5	123.1	51.3	2400.8	51.3	39.0	88.9	121.8	4.9	4.1	70.0	32.5	2.9	3.5	0.115
389	16-Mar-00	693.6	158.2	99.4	54.8	2332.2	42.6	30.4	88.6	151.2	4.5	3.9	71.4	32.8	3.4	3.4	0.128
390	17-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)															
391	18-Mar-00	No Test															
392	19-Mar-00	717.9	158.2	115.6	46.6	2697.2	42.6	30.4	87.4	154.0	4.1	3.4	70.6	31.9	2.7	2.9	0.122
393	20-Mar-00	701.7	182.5	123.7	50.7	2535.0	46.6	42.6	92.4	165.2	4.9	4.2	73.9	33.5	3.4	3.5	0.132
394	21-Mar-00	819.3	267.7	133.8	52.7	2433.6	48.7	48.7	94.4	166.6	4.6	4.2	75.9	35.0	3.1	3.1	0.115
395	22-Mar-00	731.9	213.8	135.7	65.8	2467.2	53.5	20.6	92.4	151.2	4.5	3.6	75.3	34.2	3.4	3.6	0.126
396	23-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)															
397	24-Mar-00	No Test - New Sewage fed yesterday															
BATCH 28 Averages:		***734.1***	***174.6***	***123.0***	***53.3***	***2472.6***	***50.2***	***38.6***	***90.1***	***145.9***	***4.5***	***3.8***	***72.7***	***33.1***	***3.1***	***3.3***	***0.123***
398	25-Mar-00	No Test - New Sewage															
399	26-Mar-00	686.7	143.9	113.1	51.4	2446.6	47.3	35.0	66.4	147.0	5.6	4.1	55.4	25.1	3.1	3.4	0.097
400	27-Mar-00	740.2	189.2	127.5	53.5	2097.1	53.5	45.2	69.4	149.8	5.0	4.5	56.0	26.2	3.2	3.5	0.094
401	28-Mar-00	726.2	199.9	136.7	34.7	2142.0	42.8	34.7	69.7	147.0	4.2	3.8	61.0	26.6	2.9	3.1	0.096
402	29-Mar-00	754.8	187.7	146.9	44.9	2121.6	49.0	40.8	72.4	145.6	4.9	4.2	61.3	28.0	3.5	3.8	0.096
403	30-Mar-00	775.2	187.7	126.5	61.2	2203.2	40.8	20.4	72.2	154.0	5.5	4.8	61.9	27.7	3.1	4.2	0.093
404	31-Mar-00	No Test															
405	01-Apr-00	No Test															
406	02-Apr-00	767.0	187.7	151.0	73.4	2325.6	65.3	49.0	75.2	155.4	4.2	3.8	58.0	27.3	3.2	3.5	0.098
407	03-Apr-00	716.8	172.0	127.0	57.3	2293.8	57.3	28.7	72.0	156.8	5.2	4.2	59.4	27.3	3.5	4.2	0.100
BATCH 29 Averages:		***738.1***	***181.2***	***132.6***	***53.8***	***2232.8***	***50.9***	***36.2***	***71.0***	***150.8***	***4.9***	***4.2***	***59.0***	***26.9***	***3.2***	***3.7***	***0.096***
408	04-Apr-00	New Sewage Fed Yesterday, No Test															
409	05-Apr-00	No Test - New Sewage															
410	06-Apr-00	741.4	208.9	120.8	59.4	2396.2	59.4	38.9	75.0	144.2	2.5	1.8	58.8	27.3	1.4	1.4	0.101
411	07-Apr-00	No Test															
412	08-Apr-00	No Test															
413	09-Apr-00	745.5	172.0	118.8	69.6	2252.8	45.1	36.9	74.1	140.0	1.8	1.4	56.6	25.3	0.0	0.0	0.099

		mgCOD/l							mgN/l									
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
414	10-Apr-00	766.0	208.9	120.8	75.8	2314.2	55.3	38.9	72.5	133.0	2.2	1.4	58.2	26.3	0.0	0.0	0.095
415	11-Apr-00	729.1	188.4	114.7	86.0	2211.8	53.2	36.9	75.5	140.0	4.6	3.8	61.6	28.4	3.2	3.4	0.103
416	12-Apr-00	753.7	188.4	122.9	65.5	2293.8	53.2	45.1	78.8	142.8	4.6	4.2	62.2	28.6	3.2	3.6	0.105
417	13-Apr-00	757.8	213.0	114.7	65.5	2129.9	61.4	41.0	81.3	140.0	5.2	3.8	66.1	30.2	2.9	3.1	0.107
418	14-Apr-00	No Test															
419	15-Apr-00	No Test															
420	16-Apr-00	741.4	192.5	120.8	75.8	1986.6	63.5	38.9	86.8	151.2	7.1	6.4	70.0	32.9	5.2	5.6	0.117
421	17-Apr-00	New Sewage fed today															
BATCH 30 Averages:		***747.8***	***196.0***	***119.1***	***71.1***	***2226.5***	***55.9***	***39.5***	***77.7***	***141.6***	***4.0***	***3.3***	***61.9***	***28.4***	***2.3***	***2.4***	***0.104***
422	18-Apr-00	Not Test - New Sewage (INCREASED INFLUENT TO 30 l YEST.)															
423	19-Apr-00	No Test - New Sewage															
424	20-Apr-00	Reduced influent to 25 l/d and Sludge Age to 8 days															
425	21-Apr-00	No Test - Adapt to new config.															
426	22-Apr-00	No Test - Adapt to new config.															
427	23-Apr-00	No Test - Adapt to new config.															
428	24-Apr-00	782.1	274.6	174.7	149.8	1788.8	79.0	49.9	69.3	158.2	9.1	7.6	52.1	24.4	5.0	6.4	0.089
429	25-Apr-00	740.5	158.1	153.9	79.0	2412.8	62.4	29.1	62.7	144.2	4.3	3.2	49.8	23.0	2.8	2.8	0.085
430	26-Apr-00	732.2	137.3	164.3	68.6	2683.2	68.6	47.8	62.2	147.0	4.9	3.6	48.4	21.6	2.7	2.8	0.085
431	27-Apr-00	736.3	145.6	147.7	72.8	2600.0	56.2	39.5	62.6	151.2	3.9	3.2	50.4	23.0	2.9	2.8	0.085
432	28-Apr-00	748.8	141.4	129.0	79.0	2787.2	58.2	37.4	64.5	156.8	4.5	3.2	50.4	23.2	2.5	2.5	0.086
433	29-Apr-00	No Test															
434	30-Apr-00	686.8	121.2	129.3	44.4	2383.6	60.6	28.3	63.4	156.8	3.8	2.8	49.8	23.0	2.4	2.4	0.092
435	01-May-00	711.0	137.4	149.5	72.7	2302.8	52.5	24.2	63.0	156.8	4.2	3.5	48.7	22.8	2.7	2.4	0.089
436	02-May-00	703.0	153.5	165.6	64.6	2302.8	60.6	28.3	62.6	147.0	3.8	3.2	49.0	22.7	2.1	2.8	0.089
437	03-May-00	731.2	153.5	157.6	68.7	2343.2	52.5	44.4	65.5	142.8	3.5	3.2	51.5	23.4	2.8	2.9	0.090
438	04-May-00	744.0	160.0	164.0	76.0	2320.0	64.0	32.0	67.5	142.8	4.2	3.2	49.6	27.0	2.7	2.8	0.091
BATCH 31 Averages:		***731.6***	***158.3***	***153.6***	***77.6***	***2392.4***	***61.5***	***36.1***	***64.3***	***150.4***	***4.6***	***3.7***	***50.0***	***23.4***	***2.9***	***3.1***	***0.088***
439	05-May-00	New Sewage Fed Yesterday, No Test															
440	06-May-00	No Test - New Sewage															
441	07-May-00	No Test - New Sewage															
442	08-May-00	756.0	208.0	136.0	76.0	2440.0	76.0	44.0	78.8	155.4	4.5	3.9	63.6	30.1	3.2	3.6	0.104
443	09-May-00	780.0	172.0	126.0	54.0	2380.0	58.0	38.0	80.1	149.8	5.3	4.6	65.5	28.0	3.4	4.1	0.103
444	10-May-00	756.0	192.0	140.0	68.0	2400.0	56.0	28.0	80.8	148.4	4.5	3.8	63.0	28.7	3.2	3.2	0.107
445	11-May-00	780.0	192.0	136.0	76.0	2400.0	56.0	36.0	79.9	144.2	5.3	4.2	65.0	28.0	3.4	3.5	0.102

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
446	12-May-00	776.0	188.0	134.0	86.0	2900.0	58.0	38.0	78.7	156.8	4.6	3.9	62.4	28.4	3.4	3.2	0.101
447	13-May-00	No Test															
448	14-May-00	772.0	192.0	144.0	100.0	2640.0	60.0	44.0	78.7	140.0	4.5	3.5	62.4	29.1	3.1	3.1	0.102
449	15-May-00	752.0	184.0	144.0	96.0	2360.0	52.0	40.0	79.9	133.0	4.9	3.8	64.4	27.9	3.2	3.2	0.106
450	16-May-00	No Test - No Distilled Water															
451	17-May-00	938.8	186.9	158.5	130.0	2560.3	69.1	48.8	79.5	145.6	4.8	4.1	63.8	28.0	3.2	3.4	0.085
452	18-May-00	727.5	186.9	154.4	121.9	2438.4	61.0	32.5	78.7	147.0	4.8	3.9	62.4	27.9	3.4	3.1	0.108
453	19-May-00	No Test															
454	20-May-00	No Test															
455	21-May-00	760.0	211.3	182.9	113.8	3129.3	81.3	61.0	83.9	175.0	6.4	5.5	67.8	30.8	4.5	4.2	0.110
456	22-May-00	Cleaned Unit															
BATCH 32 Averages:		***779.8***	***191.3***	***145.6***	***92.2***	***2564.8***	***62.7***	***41.0***	***79.9***	***149.5***	***5.0***	***4.1***	***64.0***	***28.7***	***3.4***	***3.5***	***0.103***
457	23-May-00	New Sewage Fed Today															
458	24-May-00	WISA															
459	25-May-00	WISA															
460	26-May-00	WISA															
461	27-May-00	WISA															
462	28-May-00	WISA															
463	29-May-00	WISA															
464	30-May-00	WISA															
465	31-May-00	WISA															
466	01-Jun-00	WISA															
467	02-Jun-00	WISA															
468	03-Jun-00	WISA															
469	04-Jun-00	Steering Committee															
470	05-Jun-00	Research Seminar															
BATCH 33 Averages:		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
471	06-Jun-00	New Sewage Fed															
472	07-Jun-00	No Test - New Sewage															
473	08-Jun-00	Reduce Sludge Age from 8 to 5 Days (install cont. waste)															
474	09-Jun-00	No Test															
475	10-Jun-00	No Test															
476	11-Jun-00	714.8	216.9	160.6	104.4	2168.6	80.3	44.2	87.5	119.0	5.9	3.6	71.1	33.6	2.8	2.8	0.122
477	12-Jun-00	662.6	192.8	152.6	92.4	1967.8	72.3	24.1	88.8	130.2	7.3	4.5	72.8	34.7	2.4	2.7	0.134

		mgCOD/l							mgN/l								
		COD							TKN				FSA				TKN/COD Ratio
Day No.	Date	UI	FFI	SETA	SETB	R	UE	FE	UI	AE	UE	FE	UI	SETA	SETB	UE	Influent
478	13-Jun-00	706.8	184.7	160.6	96.4	1807.2	92.4	32.1	89.0	152.6	7.0	4.3	73.6	34.0	2.9	3.1	0.126
479	14-Jun-00	743.0	196.8	162.6	90.4	1666.6	94.4	34.1	85.5	112.0	6.6	3.6	71.7	32.2	2.2	2.7	0.115
480	15-Jun-00	762.0	173.4	163.3	78.6	1753.9	94.8	30.2	86.8	123.2	7.1	3.6	70.0	33.3	2.0	2.0	0.114
481	16-Jun-00	665.3	185.5	157.2	80.6	1572.5	88.7	24.2	88.5	112.0	7.0	3.6	72.8	34.6	3.1	3.1	0.133
482	17-Jun-00	No Test															
483	18-Jun-00	709.6	153.2	173.4	96.8	1209.6	64.5	32.3	86.5	112.0	7.4	5.6	70.8	33.7	3.2	3.4	0.122
BATCH 34 Averages:		***709.2***	***186.2***	***161.5***	***91.4***	***1735.2***	***83.9***	***31.6***	***87.5***	***123.0***	***6.9***	***4.1***	***71.8***	***33.7***	***2.7***	***2.8***	***0.124***

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
1	22-Feb-99	0.1	0.1	0.1	2.1	0.2	0.5	0.2	1.8	0.3	0.2	4.9	0.4	3.9	3.9	23.3	5.6	40.6	27.4	33.3	16.0	9.7	4.9	4.5
2	23-Feb-99	0.1	0.1	0.1	2.5	0.4	0.4	0.2	2.6	0.3	0.2	5.7	0.9	4.6	3.5	23.3	6.2	34.7	25.0	35.1	14.9	19.8	5.6	8.7
3	24-Feb-99	0.1	0.2	0.1	3.5	0.3	0.2	0.2	2.8	0.5	0.2	10.3	1.6	4.4	4.8	14.9	4.5	5.2	20.1	29.5	12.8	5.2	6.6	5.6
4	25-Feb-99	0.1	0.1	0.1	3.7	0.1	0.2	0.1	1.5	0.5	0.2	12.8	0.7	4.0	3.1	22.2	4.2	4.2	23.3	31.2	13.2	17.7	3.1	2.4
5	26-Feb-99	No Test (SET 2 blocked up, sludge loss)																						
6	27-Feb-99	No Test (AE, ANO & SET 2 overflowed, sludge loss)																						
7	28-Feb-99	No Test (AE & SET 2 blocked, overflowed, sludge loss)																						
8	01-Mar-99	0.1	0.1	0.1	1.5	0.4	0.2	0.3	1.4	0.6	0.2	17.0	2.2	4.9	1.4	21.9	9.7	37.1	23.9	30.2	14.2	23.9	9.7	5.6
9	02-Mar-99	0.2	0.0	0.0	0.6	0.4	0.2	0.1	0.4	0.5	0.2	16.9	4.0	5.3	0.6	26.4	10.4	39.2	26.4	29.2	16.0	25.3	9.7	9.4
10	03-Mar-99	0.5	0.1	0.1	-	1.3	1.5	1.1	4.9	0.8	0.2	-	8.0	6.2	11.9	22.5	23.9	53.6	49.4	28.4	19.0	33.5	11.8	11.4
11	04-Mar-99	No Test (SmANO,ANO & AE overflowed, sludge loss) - New sewage fed today																						
BATCH 1 Averages:		***0.2***	***0.1***	***0.1***	***2.3***	***0.4***	***0.5***	***0.3***	***2.2***	***0.5***	***0.2***	***11.3***	***2.5***	***4.8***	***4.2***	***22.1***	***9.2***	***30.7***	***27.9***	***31.0***	***15.2***	***19.3***	***7.3***	***6.8***
12	05-Mar-99	No Test (New Sewage)																						
13	06-Mar-99	No Test (New Sewage)																						
14	07-Mar-99	No Test: SLUDGE FOUND IN SEWAGE - GET NEW BATCH																						
15	08-Mar-99	No Test: -New Sewage Fed today																						
BATCH 2 Averages:		***BAD BATCH***																						
16	09-Mar-99	No Test (New Sewage)																						
17	10-Mar-99	No Test (New Sewage)																						
18	11-Mar-99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	12-Mar-99	No Test																						
20	13-Mar-99	No Test																						
21	14-Mar-99	2.0	0.4	0.1	-	0.6	2.7	1.5	15.7	0.9	0.2	-	12.0	15.1	21.8	22.5	16.9	27.7	18.3	16.9	17.3	30.4	17.6	17.3
22	15-Mar-99	2.0	0.9	0.4	-	0.6	2.3	1.1	21.1	1.2	0.5	-	11.7	18.1	22.1	23.5	19.4	28.0	19.0	20.4	19.7	34.6	18.0	16.9
23	16-Mar-99	No Test (AN overflowed violently)																						
24	17-Mar-99	1.9	1.2	0.5	-	0.4	2.1	0.9	24.7	1.2	0.3	-	12.2	17.7	22.8	16.3	17.6	21.8	15.2	17.6	17.6	29.4	22.5	21.8
25	18-Mar-99	1.7	1.0	0.3	-	0.5	2.1	0.7	17.0	1.2	0.5	-	12.2	16.8	22.7	16.6	15.2	44.6	12.8	15.6	14.9	35.6	18.0	17.3
BATCH 3 Averages:		***1.9***	***0.9***	***0.3***	***-***	***0.5***	***2.3***	***1.1***	***19.6***	***1.1***	***0.4***	***-***	***12.0***	***16.9***	***22.3***	***19.7***	***17.3***	***30.5***	***16.3***	***17.6***	***17.4***	***32.5***	***19.0***	***18.3***
26	19-Mar-99	No Test (New Sewage)																						
27	20-Mar-99	No Test (New Sewage)																						
28	21-Mar-99	No Test (SmANO,AN & AE overflowed - Sludge Loss)																						
29	22-Mar-99	2.1	0.1	0.1	0.6	2.0	0.9	0.8	7.0	0.2	0.3	12.5	7.6	12.4	15.9	25.5	14.9	40.0	24.7	26.2	18.2	33.5	16.7	18.2
30	23-Mar-99	1.5	0.1	0.0	0.8	2.0	0.8	0.7	5.4	0.2	0.2	13.9	7.2	9.6	11.8	22.6	14.6	38.9	24.7	24.4	18.6	29.1	15.3	14.9
31	24-Mar-99	No Test (Install new freezer & spray SET1 black because of algae growth)																						
32	25-Mar-99	1.5	0.1	0.1	1.2	1.5	1.1	0.8	5.3	0.2	0.2	14.3	5.6	11.9	11.1	25.8	15.6	37.1	29.5	28.4	20.0	25.1	14.6	13.8
33	26-Mar-99	No Test																						
34	27-Mar-99	No Test																						
35	28-Mar-99	3.0	0.1	0.1	1.1	2.1	1.7	1.2	6.2	-	0.2	12.9	6.6	11.5	13.4	20.4	12.4	36.7	26.2	26.9	17.1	24.4	14.9	15.3

		mgN/l														mgP/l							
		Nitrite							Nitrate							Phosphates							
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
36	29-Mar-99	1.6	0.1	0.1	1.1	1.5	1.4	1.2	7.1	-	0.2	9.3	6.4	10.9	12.2	22.2	12.4	39.7	27.6	25.5	18.2	22.2	14.9	14.9
37	30-Mar-99	No Test (Influent bucket run dry)																						
38	31-Mar-99	No Test (Dregs of last sewage fed yesterday) - New sewage fed today																						
BATCH 4 Averages:		***1.9***	***0.1***	***0.1***	***1.0***	***1.8***	***1.2***	***0.9***	***6.2***	***0.2***	***0.2***	***12.6***	***6.7***	***11.3***	***12.9***	***23.3***	***14.0***	***38.5***	***26.6***	***26.3***	***18.4***	***28.8***	***15.3***	***15.4***
39	01-Apr-99	No Test (New Sewage)																						
40	02-Apr-99	No Test (New Sewage)																						
41	03-Apr-99	No Test																						
42	04-Apr-99	No Test (SmANO & Nitrifier overflowed - Sludge loss)																						
43	05-Apr-99	1.1	0.1	0.1	2.8	1.7	0.6	0.2	10.5	0.4	0.2	17.1	12.9	16.2	13.4	20.9	13.4	28.3	22.4	26.8	17.5	32.1	14.2	13.8
44	06-Apr-99	No Test (Final settler failed - sludge in effluent)																						
45	07-Apr-99	No Test (Final settler failed - sludge in effluent)																						
46	08-Apr-99	No Test (Final settler failed - sludge in effluent)																						
47	09-Apr-99	1.0	0.1	0.1	0.7	1.0	0.5	0.4	10.2	0.4	0.3	16.0	11.4	16.0	15.3	16.4	14.9	19.0	15.3	20.5	14.9	28.0	16.0	16.0
48	10-Apr-99	No Test (External Nitrifier overflowed - big sludge loss)																						
49	11-Apr-99	1.4	0.2	0.1	1.1	1.5	1.1	0.9	7.5	0.7	0.3	10.6	9.8	12.4	13.9	20.5	15.7	34.3	19.0	20.1	16.0	31.3	17.5	16.0
50	12-Apr-99	1.3	0.1	0.1	3.0	1.9	1.1	1.1	11.1	0.3	0.2	17.6	14.0	14.0	14.1	20.1	16.0	28.8	18.3	18.3	16.0	32.4	17.9	17.2
51	13-Apr-99	1.1	0.1	0.1	2.8	1.5	1.0	1.2	9.1	0.4	0.2	13.9	9.3	11.6	13.9	20.1	16.0	49.6	17.5	18.3	16.4	31.7	16.8	16.8
52	14-Apr-99	Cleaned Unit																						
53	15-Apr-99	2.1	0.1	0.0	2.6	1.8	2.1	2.1	13.1	0.4	0.2	18.2	11.0	13.8	15.2	28.0	21.6	35.0	23.5	26.1	22.4	32.4	21.6	20.9
54	16-Apr-99	0.0	-	0.1	-	1.3	1.7	1.2	9.0	0.7	0.3	15.1	15.0	13.5	15.1	22.8	16.3	34.4	21.4	27.2	20.7	31.9	22.1	22.1
BATCH 5 Averages:		***1.1***	***0.1***	***0.1***	***2.2***	***1.5***	***1.1***	***1.0***	***10.1***	***0.5***	***0.2***	***15.5***	***11.9***	***13.9***	***14.4***	***21.3***	***16.3***	***32.5***	***19.6***	***22.5***	***17.7***	***31.4***	***18.0***	***17.5***
55	17-Apr-99	No Test (New Sewage)																						
56	18-Apr-99	No Test (New Sewage)																						
57	19-Apr-99	0.0	-	0.0	-	2.1	1.9	0.9	1.4	0.6	0.2	14.9	3.7	6.9	7.7	26.8	13.4	27.5	25.4	28.6	18.8	30.1	15.2	15.2
58	20-Apr-99	No Test (AE & ANO overflowed - sludge loss)																						
59	21-Apr-99	No Test (ANO & Nitrifier overflowed - sludge loss)																						
60	22-Apr-99	0.0	-	0.0	-	2.4	4.0	-	1.1	0.3	0.2	12.1	2.3	5.6	10.1	27.5	13.4	26.8	27.9	32.2	19.6	16.3	15.2	16.3
61	23-Apr-99	No Test																						
62	24-Apr-99	No Test																						
63	25-Apr-99	No Test (ANO overflowed - sludge loss)																						
64	26-Apr-99	No Test																						
65	27-Apr-99	0.0	0.1	0.1	1.4	3.3	4.5	-	1.1	0.2	0.2	16.6	2.2	4.0	11.3	23.9	16.7	24.3	25.7	29.3	19.9	14.9	13.8	13.8
66	28-Apr-99	0.0	0.1	0.1	0.6	-	3.5	3.9	0.8	0.2	0.2	13.1	4.3	6.2	4.1	35.1	15.6	32.6	33.0	37.7	22.8	22.1	14.1	14.1
67	29-Apr-99	0.0	0.1	0.1	0.9	3.3	-	2.9	1.0	0.2	0.2	19.5	2.0	8.0	6.6	31.5	17.4	34.4	34.1	40.6	24.6	21.0	17.4	17.4
BATCH 6 Averages:		***0.0***	***0.1***	***0.1***	***1.0***	***2.8***	***3.5***	***2.5***	***1.1***	***0.3***	***0.2***	***15.2***	***2.9***	***6.1***	***8.0***	***29.0***	***15.3***	***29.1***	***29.2***	***33.7***	***21.2***	***20.9***	***15.1***	***15.4***
68	30-Apr-99	No Test (New Sewage)																						
69	01-May-99	No Test (New Sewage)																						
70	02-May-99	No Test (Nitrifier blocked, overlowing - sludge loss)																						

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
71	03-May-99	0.1	0.0	0.0	0.7	1.2	0.7	0.4	0.2	0.2	0.2	12.9	2.4	3.0	3.1	19.9	11.2	36.2	28.6	32.6	17.0	23.2	12.0	12.0
72	04-May-99	0.2	0.1	0.1	0.6	3.3	0.9	0.4	1.8	0.2	0.3	18.4	2.0	4.1	7.9	23.2	13.0	42.0	30.1	35.1	22.8	24.3	13.4	13.0
73	05-May-99	0.2	0.1	0.1	0.5	3.0	1.2	0.7	1.5	0.2	0.2	18.9	3.0	4.8	6.6	27.5	13.0	44.8	32.2	37.7	20.3	34.4	15.6	15.2
74	06-May-99	0.1	0.1	0.1	0.6	2.4	0.9	0.7	2.1	0.2	0.2	18.6	1.9	4.1	4.2	27.5	13.4	38.8	33.3	38.4	19.6	26.4	14.9	14.5
75	07-May-99	0.5	0.1	0.0	0.6	2.0	0.6	0.5	0.3	0.3	0.2	16.8	2.0	4.4	4.6	26.1	13.0	36.9	28.3	33.3	17.7	24.6	14.9	14.5
76	08-May-99	No Test																						
77	09-May-99	0.4	0.1	0.0	0.4	1.8	0.7	0.9	3.4	0.2	0.2	11.7	1.8	3.9	2.9	20.4	10.0	27.6	24.4	28.3	14.0	24.4	10.7	10.7
78	10-May-99	0.2	0.1	0.1	0.3	2.1	0.7	0.6	3.4	0.2	0.2	14.6	1.9	3.9	3.4	22.9	11.1	30.4	24.7	29.4	16.1	21.8	10.7	10.4
79	11-May-99	0.5	0.2	0.1	0.6	2.7	1.3	0.9	2.3	0.3	0.1	15.9	3.8	5.9	4.8	21.5	9.0	25.4	24.7	29.4	15.0	17.6	12.5	11.8
80	12-May-99	1.3	0.1	0.1	0.4	2.5	1.2	1.0	1.0	0.2	0.1	18.2	4.5	6.6	5.8	17.9	7.9	20.4	21.1	26.1	13.3	21.8	10.0	10.0
81	13-May-99	1.2	0.1	0.1	0.2	2.1	1.0	0.9	1.5	0.2	0.1	15.5	4.3	6.3	6.2	27.6	10.4	27.6	24.7	27.6	15.0	18.3	10.4	10.4
82	14-May-99	No Test (New Sewage Fed today)																						
BATCH 7 Averages:		***0.5***	***0.1***	***0.1***	***0.5***	***2.3***	***0.9***	***0.7***	***1.7***	***0.2***	***0.2***	***16.1***	***2.8***	***4.7***	***4.9***	***23.5***	***11.2***	***33.0***	***27.2***	***31.8***	***17.1***	***23.7***	***12.5***	***12.3***
83	15-May-99	No Test (New Sewage)																						
84	16-May-99	2.0	0.2	0.1	0.2	1.7	1.3	1.2	2.6	0.5	0.2	21.2	8.9	10.5	10.8	24.0	17.9	31.5	24.0	29.0	21.8	31.5	20.4	19.7
85	17-May-99	3.6	0.2	0.0	0.6	3.1	3.6	1.9	10.0	0.6	0.1	20.2	16.0	11.3	14.8	25.5	19.2	27.6	25.2	29.7	20.6	27.6	22.4	21.3
86	18-May-99	4.1	0.2	0.1	0.6	4.0	2.9	2.2	5.6	0.4	0.2	21.6	8.5	12.6	11.7	25.2	17.1	34.3	29.4	33.2	21.7	27.6	21.0	20.3
87	19-May-99	No Test (Batch Test 1 for Phosphates)																						
88	20-May-99	No Test (Batch Test 1 for Phosphates)																						
89	21-May-99	No Test																						
90	22-May-99	No Test																						
91	23-May-99	No Test (Batch Test 2 for Phosphates)																						
92	24-May-99	3.5	0.2	0.1	1.3	3.4	2.7	2.5	6.0	0.3	0.1	23.9	9.6	10.9	12.6	25.5	16.4	25.9	27.3	30.8	21.3	17.8	18.9	17.8
93	25-May-99	4.1	0.2	0.1	1.4	3.6	3.2	3.2	5.0	0.4	0.1	24.6	9.0	10.2	10.2	28.7	17.1	28.0	29.4	31.5	22.4	18.9	19.2	18.9
94	26-May-99	3.4	0.2	0.1	2.7	4.1	3.4	2.7	3.2	0.3	0.2	17.6	5.4	7.7	9.9	28.3	16.8	28.7	30.8	32.2	22.0	18.5	19.9	19.2
95	27-May-99	3.5	0.2	0.1	3.6	3.6	3.2	2.5	1.2	0.3	0.2	17.3	5.1	7.2	7.3	25.2	16.8	27.3	29.0	30.8	21.3	17.8	20.3	18.5
96	28-May-99	No Test																						
97	29-May-99	No Test																						
98	30-May-99	No Test (Dregs of last sewage fed yesterday) - New sewage fed today																						
BATCH 8 Averages:		***3.5***	***0.2***	***0.1***	***1.5***	***3.4***	***2.9***	***2.3***	***4.8***	***0.4***	***0.2***	***20.9***	***9.0***	***10.1***	***11.0***	***26.0***	***17.3***	***29.0***	***27.8***	***31.0***	***21.6***	***22.8***	***20.3***	***19.4***
99	31-May-99	No Test (New Sewage)																						
100	01-Jun-99	No Test (New Sewage)																						
101	02-Jun-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.1	4.0	1.2	2.5	0.0	22.5	17.7	21.8	23.9	24.6	20.1	18.7	19.7	19.4
102	03-Jun-99	No Test - Bad batch - Feed new sewage today																						
BATCH 9 Averages:		***BAD BATCH***																						
103	04-Jun-99	No Test (New Sewage)																						
104	05-Jun-99	No Test (New Sewage)																						
105	06-Jun-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.2	0.1	4.4	2.1	3.2	5.3	29.1	18.7	26.0	27.0	25.6	21.1	18.7	16.6	16.3

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
106	07-Jun-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.1	4.4	1.2	2.9	2.9	24.9	18.0	23.2	23.9	24.6	20.8	18.3	19.4	18.7
107	08-Jun-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.2	0.1	6.0	0.3	2.4	1.9	23.2	18.3	22.8	23.5	23.9	19.4	16.6	18.7	17.7
108	09-Jun-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1	0.1	4.4	0.5	2.9	1.9	21.8	16.3	22.8	22.8	23.2	18.3	15.9	18.0	17.0
109	10-Jun-99	No Test																						
110	11-Jun-99	No Test - SmANO overflowed																						
111	12-Jun-99	No Test																						
112	13-Jun-99	Cleaned Unit																						
113	14-Jun-99	No Test - (recouperate) - DO Probe & Box installed on Nitrifier																						
114	15-Jun-99	No Test - Replace both DO boxes, re-install, service & calibrate probes																						
115	16-Jun-99	0.4	0.1	0.1	1.4	0.5	2.7	2.2	0.3	0.0	0.1	2.3	0.0	0.3	0.3	23.5	12.4	23.5	24.5	17.1	15.1	12.1	13.8	12.8
116	17-Jun-99	0.5	0.1	0.1	3.9	0.5	2.9	2.9	0.2	0.1	0.1	0.5	0.0	0.4	0.3	25.5	11.8	25.2	25.9	17.5	14.8	11.4	12.4	12.4
117	18-Jun-99	No Test																						
118	19-Jun-99	No Test																						
119	20-Jun-99	0.5	0.1	0.1	6.9	2.2	4.7	4.0	0.0	0.1	0.1	-0.4	-0.2	0.2	0.4	28.6	14.1	27.2	28.6	24.5	18.5	15.1	14.1	13.4
120	21-Jun-99	0.5	0.1	0.1	8.2	3.4	4.5	4.0	0.0	0.1	0.1	-0.6	-0.0	0.3	0.5	21.2	14.1	23.5	25.2	20.8	17.1	15.1	16.5	16.1
121	22-Jun-99	0.5	0.1	0.1	2.6	0.6	3.4	2.7	1.6	0.1	0.1	0.0	0.1	0.4	0.5	20.5	14.4	22.8	25.2	20.5	17.8	15.1	15.5	15.5
122	23-Jun-99	0.6	0.1	0.1	8.9	3.0	2.9	2.4	-0.0	0.1	0.1	-0.2	-0.3	0.5	1.0	21.2	9.7	19.5	22.5	17.8	13.4	10.8	13.1	12.8
123	24-Jun-99	No Test - Hydraulics Invidulation																						
124	25-Jun-99	No Test -Exam																						
125	26-Jun-99	No Test -Exam																						
126	27-Jun-99	No Test -Exam																						
127	28-Jun-99	0.0	0.0	0.6	14.9	1.4	0.4	1.0	0.5	0.1	0.2	0.3	0.2	0.5	1.4	19.2	12.1	20.9	26.0	19.9	14.2	10.8	11.1	11.1
128	29-Jun-99	No Test																						
129	30-Jun-99	0.5	0.1	0.1	17.6	8.3	5.4	1.9	0.5	0.1	0.1	1.4	-0.1	1.5	1.3	15.2	6.7	14.8	18.2	19.2	12.1	9.1	9.4	9.1
130	01-Jul-99	0.0	0.0	0.1	17.2	4.3	2.2	0.6	0.4	0.1	0.1	1.0	-0.0	0.9	0.8	28.0	13.5	25.0	27.0	26.7	19.2	14.5	10.1	9.8
131	02-Jul-99	0.0	0.0	0.0	16.5	4.2	1.8	0.9	1.2	0.1	0.1	1.2	0.3	0.8	1.1	30.7	16.9	27.7	31.4	31.0	21.9	18.2	16.5	16.2
132	03-Jul-99	No Test																						
133	04-Jul-99	No Test (Stirrer on SET2 failed)																						
134	05-Jul-99	No Test (Dregs of last sewage) - New Sewage fed today																						
BATCH 10 Averages:		***0.2***	***0.0***	***0.1***	***7.0***	***2.0***	***2.2***	***1.6***	***0.6***	***0.1***	***0.1***	***1.8***	***0.3***	***1.2***	***1.4***	***23.8***	***14.1***	***23.2***	***25.1***	***22.3***	***17.4***	***14.4***	***14.7***	***14.2***
135	06-Jul-99	4.1	0.2	0.3	25.3	12.7	13.6	4.5	0.3	0.1	0.1	0.9	0.4	2.1	1.1	22.9	15.9	27.3	33.4	34.1	24.0	18.6	19.9	18.9
136	07-Jul-99	10.4	0.3	0.5	32.4	18.2	16.7	14.1	2.0	0.1	0.2	-0.8	0.1	3.4	2.7	22.2	10.6	21.8	28.8	29.5	18.6	12.4	13.8	13.1
137	08-Jul-99	8.2	0.3	0.7	32.7	16.3	15.6	14.8	0.9	0.1	0.1	-0.9	0.9	3.0	2.5	24.8	12.4	21.8	28.0	31.7	19.7	14.2	15.7	14.6
138	09-Jul-99	7.1	0.3	0.4	33.3	15.8	13.9	14.0	1.5	0.1	0.1	-0.3	0.6	3.8	4.0	30.9	20.0	28.0	32.8	38.2	27.7	23.3	20.0	17.8
139	10-Jul-99	4.7	0.2	0.5	30.4	14.7	12.0	12.5	0.3	0.1	0.2	0.2	1.0	4.3	3.3	25.5	22.9	27.7	32.0	37.5	28.4	24.8	25.5	24.8
140	11-Jul-99	2.8	0.2	0.6	26.9	12.1	8.6	8.1	1.9	0.2	0.2	-0.5	1.1	4.7	6.0	22.2	17.5	24.8	29.8	29.8	23.3	19.7	24.0	22.9
141	12-Jul-99	No Test																						
142	13-Jul-99	1.9	0.2	0.2	25.5	10.7	6.0	5.1	3.1	0.2	0.3	6.4	3.1	9.2	9.5	28.7	21.0	26.0	32.9	33.2	26.8	23.3	21.8	21.4

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
143	14-Jul-99	1.9	0.1	0.1	25.7	10.1	7.7	5.0	3.1	0.2	0.8	5.4	3.7	9.2	9.2	23.7	16.4	24.8	28.7	29.0	22.5	21.0	22.9	21.0
144	15-Jul-99	1.3	0.0	0.1	10.1	4.5	7.0	5.0	3.4	0.1	0.2	2.6	0.8	9.2	8.8	24.1	13.4	24.5	28.3	27.5	19.9	14.9	18.7	16.4
145	16-Jul-99	Cleaned Unit																						
146	17-Jul-99	No Test (Recouperate)																						
147	18-Jul-99	6.5	0.1	0.4	9.1	6.5	10.5	10.6	3.1	0.1	0.2	5.0	2.4	8.7	7.1	22.5	9.2	17.6	19.9	24.1	15.7	12.6	10.3	9.9
148	19-Jul-99	2.4	0.1	0.3	7.0	4.2	6.2	7.1	4.8	0.2	0.2	9.4	5.4	11.5	10.5	24.5	11.5	24.5	26.8	30.6	19.1	14.9	14.9	13.8
149	20-Jul-99	No Test (Steering Commitee Meeting)																						
150	21-Jul-99	0.1	0.0	0.2	4.1	0.6	0.2	0.5	3.6	0.2	0.4	15.7	4.6	1.5	12.1	23.2	17.6	25.1	25.5	32.2	21.3	19.1	16.5	15.4
151	22-Jul-99	0.1	0.0	0.1	1.7	0.5	0.5	0.8	11.5	0.2	0.3	19.5	12.7	13.1	11.3	21.0	10.1	13.9	17.6	21.7	15.7	12.4	15.7	15.0
152	23-Jul-99	No Test (New Sewage Fed Today)																						
BATCH 11 Averages:		***4.0***	***0.2***	***0.3***	***20.3***	***9.8***	***9.1***	***7.9***	***3.1***	***0.2***	***0.2***	***4.8***	***2.8***	***6.4***	***6.8***	***24.3***	***15.3***	***23.7***	***28.0***	***30.7***	***21.7***	***17.8***	***18.4***	***17.3***
153	24-Jul-99	No Test (New Sewage)																						
154	25-Jul-99	No Test (Electricity off)																						
155	26-Jul-99	0.1	0.0	0.1	0.7	0.2	0.2	0.2	10.6	0.3	0.2	18.7	13.3	13.1	10.5	31.5	13.9	25.5	28.1	31.1	21.0	16.5	14.2	13.9
156	27-Jul-99	0.1	0.0	0.2	0.7	0.3	0.2	0.2	10.6	0.2	0.4	22.8	15.2	14.8	13.6	30.7	19.8	24.3	28.1	34.8	26.2	22.1	22.1	19.5
157	28-Jul-99	0.1	0.0	0.1	0.4	0.1	0.0	0.2	6.0	0.2	0.2	22.5	10.3	9.1	10.4	26.6	12.0	30.0	31.5	33.7	21.7	14.2	19.1	17.2
158	29-Jul-99	No Test (Nitrifier blocked up & overflowed violently)																						
159	30-Jul-99	0.1	0.0	0.0	1.2	0.3	0.1	0.2	7.9	0.2	0.2	18.1	10.4	10.5	10.3	33.0	21.0	24.3	30.0	31.8	25.5	22.8	20.6	20.2
160	31-Jul-99	No Test																						
161	01-Aug-99	No Test - Air off for 24 hours, entire system anoxic/anaerobic																						
162	02-Aug-99	0.4	0.1	0.1	1.2	0.9	0.2	1.9	8.6	0.3	0.3	19.8	12.8	13.9	10.6	27.9	3.3	16.2	22.1	21.3	9.9	5.1	14.7	14.0
163	03-Aug-99	0.4	0.0	0.0	0.9	0.6	0.1	0.2	7.3	0.3	0.3	24.2	12.8	10.9	12.4	25.0	5.1	20.2	20.9	23.5	12.9	7.7	7.0	6.2
164	04-Aug-99	No Test - Power cut, DO boxes reset, no air																						
165	05-Aug-99	0.5	0.0	0.0	1.5	0.9	0.9	0.5	6.5	0.2	0.3	22.9	8.3	9.6	12.0	30.1	13.6	26.1	29.0	32.3	20.9	15.4	13.6	13.6
166	06-Aug-99	0.2	0.0	0.0	0.9	0.4	0.2	0.7	6.6	0.2	0.3	25.1	11.8	10.9	11.0	31.6	19.8	32.3	35.6	39.0	27.2	22.4	20.9	20.2
BATCH 12 Averages:		***0.3***	***0.0***	***0.1***	***0.9***	***0.5***	***0.3***	***0.5***	***8.0***	***0.3***	***0.3***	***21.8***	***11.9***	***11.6***	***11.3***	***29.5***	***13.6***	***24.9***	***28.2***	***30.9***	***20.7***	***15.8***	***16.5***	***15.6***
167	07-Aug-99	No Test - New Sewage																						
168	08-Aug-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.2	9.1	0.2	0.2	0.0	21.2	17.9	22.0	26.4	29.0	19.0	14.5	14.9	14.5
169	09-Aug-99	0.2	0.0	0.0	0.3	0.5	0.1	0.1	4.3	0.2	0.3	23.5	12.1	11.2	4.5	24.6	11.2	20.5	23.8	27.2	17.5	12.7	13.8	13.0
170	10-Aug-99	0.3	0.0	0.0	0.4	0.9	0.3	0.3	8.6	0.3	0.3	34.5	16.1	16.1	12.1	29.0	14.5	19.3	23.8	26.4	19.3	16.7	14.1	13.8
171	11-Aug-99	0.4	0.0	0.0	0.1	0.6	0.2	0.3	7.7	0.4	0.4	25.2	13.4	15.5	12.1	29.4	17.9	22.7	26.0	30.5	22.3	19.7	16.7	16.4
172	12-Aug-99	No Test - Cleaned Unit																						
173	13-Aug-99	0.6	0.5	0.3	0.1	0.7	0.3	0.6	15.8	1.1	0.6	27.4	15.2	19.1	16.2	27.5	19.7	20.1	21.2	22.3	21.2	20.5	20.8	20.1
174	14-Aug-99	No Test																						
175	15-Aug-99	0.2	0.0	0.0	0.0	0.4	0.2	0.2	10.0	0.3	0.6	20.6	11.2	12.4	17.8	23.3	17.6	17.6	18.4	19.7	18.4	17.2	18.8	18.8
176	16-Aug-99	0.1	0.0	0.0	0.1	0.4	0.2	0.4	11.7	0.2	0.2	28.4	15.6	15.6	13.9	27.7	20.5	20.9	22.1	25.7	21.7	20.5	19.7	19.2
177	17-Aug-99	0.1	0.0	0.0	0.1	0.3	0.2	0.2	11.3	0.3	0.3	29.5	18.5	18.6	17.3	26.5	17.6	19.2	21.3	24.9	20.9	18.8	20.5	19.7
178	18-Aug-99	0.3	0.0	0.0	0.1	0.4	0.2	0.2	11.0	0.2	0.3	29.0	16.9	17.9	17.1	27.7	16.4	19.7	23.7	24.9	20.1	18.0	19.2	18.0

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
179	19-Aug-99	0.3	0.0	0.0	0.1	0.3	0.3	0.2	11.9	0.2	0.2	32.6	15.6	16.7	16.2	27.7	16.8	22.9	25.3	26.9	20.5	18.0	18.4	17.6
180	20-Aug-99	0.5	0.0	0.0	0.1	0.6	0.3	0.1	10.5	0.2	0.2	25.1	12.5	14.5	15.5	27.7	17.2	18.8	21.3	23.7	20.1	18.0	18.8	18.0
181	21-Aug-99	No Test																						
182	22-Aug-99	1.1	0.0	0.0	0.1	1.1	0.4	0.8	11.1	0.3	0.3	25.3	16.6	16.1	17.0	24.1	14.5	18.1	18.4	21.2	17.7	15.9	18.1	17.7
183	23-Aug-99	1.4	0.0	0.0	0.5	1.4	0.6	0.3	10.5	0.3	0.2	23.3	14.7	15.2	16.2	23.4	15.9	15.9	18.1	19.5	17.3	17.0	16.6	16.6
184	24-Aug-99	1.1	0.0	0.0	0.1	1.1	0.5	0.4	9.8	0.2	0.2	24.7	13.7	14.7	13.7	23.7	15.2	16.6	17.7	19.5	17.3	15.9	18.8	17.0
185	25-Aug-99	0.6	0.0	0.0	0.1	0.8	0.1	0.2	10.6	0.3	0.2	30.6	15.3	15.3	14.8	23.4	14.5	17.7	18.4	21.6	17.3	15.6	17.3	15.9
186	26-Aug-99	0.4	0.0	0.0	0.1	0.7	0.1	0.1	9.0	0.3	0.2	30.8	16.9	15.4	15.0	22.7	14.2	18.1	19.1	21.6	17.7	15.9	16.3	16.3
BATCH 13 Averages:		***0.5***	***0.1***	***0.0***	***0.2***	***0.6***	***0.3***	***0.3***	***9.6***	***0.3***	***0.3***	***26.2***	***14.0***	***14.6***	***13.7***	***25.6***	***16.4***	***19.4***	***21.6***	***24.0***	***19.3***	***17.2***	***17.7***	***17.1***
187	27-Aug-99	No Test (New Sewage)																						
188	28-Aug-99	No Test (New Sewage)																						
189	29-Aug-99	0.1	0.0	0.0	0.0	0.3	0.3	0.1	4.1	0.3	0.7	15.9	10.7	12.2	13.6	20.6	12.1	21.3	22.8	25.0	14.7	13.6	14.3	14.3
190	30-Aug-99	0.3	0.0	0.0	0.6	0.5	0.3	0.2	7.2	0.2	0.2	12.6	8.9	8.0	9.6	25.7	12.8	23.5	27.5	28.3	19.1	14.3	13.2	13.2
191	31-Aug-99	0.4	0.0	0.0	0.0	0.5	0.2	0.2	3.7	0.2	0.2	17.9	8.1	9.9	8.1	27.9	12.8	26.8	29.0	30.1	18.7	15.1	15.1	15.1
192	01-Sep-99	0.5	0.0	0.0	0.2	0.8	0.3	0.5	2.4	0.1	0.2	16.9	6.7	7.2	9.7	24.2	13.6	24.6	28.6	30.5	19.1	15.8	15.8	15.8
193	02-Sep-99	0.4	0.0	0.0	0.5	0.6	0.2	0.2	6.5	0.2	0.2	15.4	7.2	7.0	6.7	29.7	14.0	27.9	30.8	32.3	21.3	16.2	16.2	16.2
194	03-Sep-99	0.2	0.0	0.0	0.0	0.4	0.1	0.2	6.9	0.2	0.2	17.4	10.6	9.9	7.9	25.7	13.2	25.0	26.4	29.7	19.5	15.4	16.2	15.8
195	04-Sep-99	No Test (Changed Main ANO to 9l and Main AE to 4l)																						
196	05-Sep-99	0.1	0.0	0.0	0.1	0.9	1.0	0.8	0.3	0.2	0.1	18.0	5.8	7.0	6.0	20.2	15.1	24.6	27.9	29.4	19.8	17.6	19.1	18.4
197	06-Sep-99	0.5	0.0	0.0	0.1	0.9	0.5	0.6	7.3	0.2	0.5	19.6	7.6	9.9	7.2	20.9	11.4	21.3	25.3	27.5	16.9	15.4	17.6	17.3
198	07-Sep-99	0.2	0.0	0.0	0.1	0.6	0.4	0.3	4.7	0.2	0.2	23.9	8.6	9.2	8.1	20.9	9.9	20.6	23.5	26.1	16.9	14.0	14.0	13.2
199	08-Sep-99	0.3	0.0	0.0	0.1	0.7	0.4	0.3	7.2	0.3	0.2	21.5	10.8	11.1	9.9	20.2	13.2	17.6	20.9	23.9	16.5	15.4	14.7	15.1
200	09-Sep-99	0.2	0.0	0.0	0.1	0.5	0.4	0.4	7.5	0.3	0.2	21.2	13.1	12.0	11.9	22.4	14.0	14.3	20.6	23.5	18.7	17.3	16.2	16.2
201	10-Sep-99	0.2	0.0	0.0	0.2	0.5	0.4	0.3	7.8	0.2	0.2	21.7	11.6	12.4	11.8	22.0	13.6	16.5	20.2	22.4	17.6	17.3	16.5	16.2
202	11-Sep-99	No Test																						
203	12-Sep-99	No Test - Dregs of sewage batch																						
BATCH 14 Averages:		***0.3***	***0.0***	***0.0***	***0.2***	***0.6***	***0.4***	***0.3***	***5.5***	***0.2***	***0.2***	***18.5***	***9.1***	***9.6***	***9.2***	***23.4***	***13.0***	***22.0***	***25.3***	***27.4***	***18.2***	***15.6***	***15.7***	***15.5***
204	13-Sep-99	No Test - New Sewage																						
205	14-Sep-99	No Test - New Sewage																						
206	15-Sep-99	No Test - AN overflowed																						
207	16-Sep-99	1.0	0.0	0.0	0.4	1.0	1.2	1.2	12.7	0.2	0.4	13.7	11.3	13.2	9.7	25.1	12.9	16.7	20.2	19.4	16.0	15.6	14.5	14.5
208	17-Sep-99	No Test																						
209	18-Sep-99	No Test																						
210	19-Sep-99	0.3	0.0	0.0	0.1	0.5	0.4	0.3	10.4	0.2	0.2	24.3	14.1	14.3	12.7	26.3	14.1	20.2	24.0	27.0	18.6	16.4	16.0	14.8
211	20-Sep-99	0.2	0.0	0.0	0.0	0.4	0.3	0.3	10.7	0.2	0.2	25.1	13.9	13.6	12.8	17.1	12.9	20.9	23.2	24.7	16.7	14.8	15.6	14.8
212	21-Sep-99	0.2	0.0	0.0	0.0	0.2	0.2	0.3	10.0	0.2	0.2	23.6	12.8	13.0	13.9	33.5	14.8	24.7	28.2	30.8	20.5	17.5	14.8	14.8
213	22-Sep-99	0.1	0.0	0.0	0.1	0.2	0.3	0.3	7.9	0.2	0.1	21.7	12.6	13.3	13.4	33.9	19.8	28.5	32.3	36.9	25.1	22.8	20.2	20.2
214	23-Sep-99	No Test - Electricity off																						

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
215	24-Sep-99	No Test																						
216	25-Sep-99	No Test																						
BATCH 15 Averages:		***0.4***	***0.0***	***0.0***	***0.1***	***0.5***	***0.5***	***0.5***	***10.3***	***0.2***	***0.3***	***21.7***	***13.0***	***13.5***	***12.5***	***27.2***	***14.9***	***22.2***	***25.6***	***27.8***	***19.4***	***17.4***	***16.2***	***15.8***
217	26-Sep-99	New Sewage																						
218	27-Sep-99	No Test - New Batch																						
219	28-Sep-99	0.3	0.0	0.0	0.1	0.5	0.4	0.3	1.6	0.2	0.2	21.4	6.9	7.8	8.9	29.7	15.4	26.7	29.7	31.2	21.0	17.3	19.2	19.2
220	29-Sep-99	0.1	0.0	0.1	0.2	0.8	0.6	1.0	0.1	0.1	0.2	21.8	4.1	5.3	5.9	28.9	16.5	28.6	31.2	31.6	20.7	17.3	18.8	18.0
221	30-Sep-99	0.1	0.0	0.1	0.1	0.4	0.4	0.6	0.0	0.1	0.1	22.9	1.6	2.9	3.2	28.2	18.0	30.4	31.2	31.9	19.9	16.5	16.9	16.9
222	01-Oct-99	0.1	0.0	0.0	0.1	0.3	0.2	0.2	0.1	0.1	0.1	19.5	1.3	1.1	1.0	28.2	16.9	30.1	31.6	33.1	20.7	17.3	17.3	16.5
223	02-Oct-99	No Test																						
224	03-Oct-99	0.1	0.0	0.0	0.1	1.3	0.6	0.3	0.1	0.1	0.1	21.2	4.8	6.4	3.3	24.0	15.0	30.1	32.3	33.4	20.3	16.9	18.0	17.3
225	04-Oct-99	0.4	0.0	0.1	0.0	0.9	0.3	0.4	0.6	0.2	0.2	23.4	3.7	3.0	4.1	24.1	12.8	29.0	30.9	32.4	18.8	15.8	15.8	15.8
226	05-Oct-99	0.8	0.0	0.1	0.0	1.8	0.9	0.7	1.7	0.1	0.2	20.5	4.6	7.2	7.1	26.0	13.2	30.5	32.4	32.8	20.0	15.1	15.1	14.7
227	06-Oct-99	0.3	0.0	0.1	0.1	1.7	1.0	0.8	0.5	0.1	0.2	22.3	7.0	7.0	6.7	26.0	12.8	30.5	31.6	32.8	20.0	15.8	16.2	15.8
228	07-Oct-99	0.7	0.0	0.1	0.1	1.6	0.9	0.6	0.4	0.1	0.2	23.0	6.4	6.5	4.9	25.6	11.7	29.4	31.2	32.8	18.4	15.1	15.8	15.8
229	08-Oct-99	0.8	0.0	0.1	0.1	1.8	1.3	0.7	1.6	0.1	0.4	22.3	7.0	7.0	5.0	26.7	12.0	28.2	30.9	33.9	20.0	16.2	14.7	14.3
230	09-Oct-99	No Test																						
231	10-Oct-99	SET 2 overflowed - No Test																						
BATCH 16 Averages:		***0.3***	***0.0***	***0.1***	***0.1***	***1.1***	***0.7***	***0.6***	***0.7***	***0.1***	***0.2***	***21.8***	***4.7***	***5.4***	***5.0***	***26.7***	***14.4***	***29.3***	***31.3***	***32.6***	***20.0***	***16.3***	***16.8***	***16.4***
232	11-Oct-99	New Sewage																						
233	12-Oct-99	No Test - New Batch																						
234	13-Oct-99	0.0	0.0	0.0	0.1	1.5	0.5	0.3	0.1	0.1	0.1	14.3	3.4	4.3	3.7	20.0	12.3	25.0	27.7	31.5	18.1	13.8	14.6	14.6
235	14-Oct-99	0.0	0.0	0.0	0.1	1.2	0.4	0.2	0.1	0.1	0.1	15.2	2.7	4.3	2.8	22.3	10.4	24.6	25.3	29.2	16.5	13.1	13.1	12.7
236	15-Oct-99	0.7	0.0	0.0	0.0	1.6	0.8	0.3	0.5	0.1	0.1	17.5	5.8	6.3	5.0	23.0	11.9	23.4	24.2	29.2	18.4	15.7	13.8	13.8
237	16-Oct-99	No Test																						
238	17-Oct-99	0.0	0.0	0.1	0.0	1.4	0.7	0.3	0.1	0.1	0.1	12.8	2.4	3.4	3.5	24.2	13.1	26.1	26.9	29.6	20.4	17.3	16.5	16.5
239	18-Oct-99	No Test (Stephanie Batch Test - 3l from AN)																						
240	19-Oct-99	0.1	0.0	0.0	0.1	1.2	0.6	0.4	0.1	0.1	0.1	18.0	2.7	4.3	5.2	25.0	14.2	28.0	30.3	33.0	20.0	17.3	16.9	16.1
241	20-Oct-99	0.2	0.0	0.1	0.1	1.5	0.8	0.7	0.2	0.1	0.1	5.2	2.2	4.5	3.6	27.5	15.8	31.7	33.8	35.2	21.8	19.0	18.7	18.0
242	21-Oct-99	1.1	0.0	0.0	0.1	1.9	0.6	0.5	1.9	0.1	0.1	11.8	4.7	4.2	3.5	26.4	16.2	24.3	26.4	29.6	21.5	19.4	20.4	19.7
243	22-Oct-99	1.4	0.1	0.0	0.1	2.4	1.6	0.9	2.9	0.1	0.1	16.7	6.0	7.4	5.7	25.0	16.2	23.2	25.7	29.6	22.2	20.1	19.7	19.7
244	23-Oct-99	No Test																						
245	24-Oct-99	1.5	0.0	0.0	0.1	2.7	1.4	0.9	1.8	0.1	0.1	17.0	4.7	6.1	5.9	25.0	17.3	22.9	24.6	28.2	21.8	20.1	19.7	19.7
BATCH 17 Averages:		***0.6***	***0.0***	***0.0***	***0.1***	***1.7***	***0.8***	***0.5***	***0.8***	***0.1***	***0.1***	***14.3***	***3.8***	***5.0***	***4.3***	***24.3***	***14.1***	***25.5***	***27.2***	***30.6***	***20.1***	***17.3***	***17.0***	***16.8***
246	25-Oct-99	New Sewage Fed Today, Cleaned Unit, 3l AN for Stephanie																						
247	26-Oct-99	No Test - New Batch																						
248	27-Oct-99	No Test - New Batch																						
249	28-Oct-99	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.4	0.1	0.2	15.7	-0.1	0.6	0.8	26.1	18.3	32.0	34.9	35.6	21.8	18.0	19.4	19.4

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
250	29-Oct-99	0.1	0.0	0.0	0.1	0.8	0.1	0.1	0.1	0.1	0.1	13.5	0.7	0.9	2.4	26.8	18.0	30.6	30.6	34.9	22.2	19.4	19.7	19.7
251	30-Oct-99	No Test																						
252	31-Oct-99	0.0	0.0	0.0	0.2	1.0	1.1	0.2	0.1	0.1	0.2	9.3	0.4	1.5	2.4	26.6	17.7	31.2	32.2	34.0	20.9	18.1	18.8	18.1
253	01-Nov-99	0.0	0.0	0.0	0.2	0.9	0.4	0.3	0.1	0.1	0.1	11.7	0.6	2.4	1.5	28.7	17.7	31.2	31.2	31.9	20.9	18.1	18.4	18.1
254	02-Nov-99	0.0	0.0	0.0	0.1	0.2	0.1	0.5	0.1	0.2	0.2	13.4	0.2	1.1	0.7	29.0	18.4	31.9	33.3	35.1	21.6	17.4	17.0	16.6
255	03-Nov-99	0.0	0.0	0.1	0.4	0.1	0.1	0.1	0.2	0.1	0.2	12.9	-0.0	0.7	1.1	30.1	18.4	34.0	36.5	36.5	22.3	17.7	18.1	17.7
256	04-Nov-99	0.0	0.0	0.0	0.4	0.5	0.2	0.1	0.1	0.1	0.1	16.2	0.4	0.8	0.3	30.8	19.1	32.9	35.1	36.5	22.0	18.8	18.4	17.7
257	05-Nov-99	No Test - Nitrifier Overflowed																						
258	06-Nov-99	No Test																						
259	07-Nov-99	0.1	0.0	0.1	0.2	1.1	0.6	0.1	0.1	0.1	0.1	11.7	0.4	1.4	0.5	26.9	17.7	28.3	30.1	32.6	20.5	17.7	17.0	17.0
BATCH 18 Averages:		***0.0***	***0.0***	***0.0***	***0.2***	***0.6***	***0.3***	***0.2***	***0.1***	***0.1***	***0.2***	***13.0***	***0.3***	***1.2***	***1.2***	***28.1***	***18.2***	***31.5***	***33.0***	***34.6***	***21.5***	***18.1***	***18.3***	***18.0***
260	08-Nov-99	New Sewage Fed Today																						
261	09-Nov-99	No Test - New Batch																						
262	10-Nov-99	No Test - New Batch																						
263	11-Nov-99	0.8	0.0	0.0	0.5	1.7	1.2	0.9	1.1	0.1	0.2	19.2	7.1	6.9	5.9	25.8	15.6	23.0	29.0	32.2	21.2	18.0	17.0	17.0
264	12-Nov-99	1.3	0.0	0.1	0.8	2.1	1.6	1.5	2.1	0.1	0.2	19.2	6.6	6.7	7.1	25.5	16.3	25.1	26.9	29.7	20.9	18.4	17.3	17.0
265	13-Nov-99	No Test																						
266	14-Nov-99	0.7	0.0	0.0	0.1	1.1	1.0	0.9	3.6	0.1	0.2	21.4	8.2	8.6	7.1	12.4	11.3	17.0	19.1	23.7	15.2	13.1	13.8	13.4
267	15-Nov-99	0.9	0.0	0.0	0.4	0.9	1.5	0.6	2.4	0.1	0.1	18.2	6.2	5.7	5.8	25.1	12.0	23.3	25.1	28.7	17.7	14.1	13.4	13.1
268	16-Nov-99	No Test - Stephanie Batch Test Yesterday (3l AN)																						
269	17-Nov-99	0.3	0.0	0.0	0.1	0.7	0.7	0.7	3.5	0.1	0.2	19.6	6.1	7.6	9.8	20.9	12.9	21.9	25.1	28.5	18.1	17.1	16.4	16.0
270	18-Nov-99	0.3	0.0	0.0	0.1	0.9	0.7	0.5	4.5	0.1	0.1	20.4	9.1	8.8	8.1	18.1	12.2	18.8	21.6	24.7	17.1	15.3	16.0	15.7
271	19-Nov-99	0.3	0.0	0.0	0.1	0.6	0.5	0.5	4.6	0.1	0.1	22.8	8.5	8.8	10.0	22.6	13.2	19.5	22.6	25.8	17.7	16.4	15.3	14.6
BATCH 19 Averages:		***0.7***	***0.0***	***0.0***	***0.3***	***1.2***	***1.0***	***0.8***	***3.1***	***0.1***	***0.2***	***20.1***	***7.4***	***7.6***	***7.7***	***21.5***	***13.4***	***21.2***	***24.2***	***27.6***	***18.3***	***16.1***	***15.6***	***15.3***
272	20-Nov-99	No Test - New Batch																						
273	21-Nov-99	0.0	0.0	0.1	0.1	0.1	0.2	0.2	-0.0	0.1	0.1	18.8	-0.1	0.9	1.8	29.2	17.4	29.6	31.7	33.1	20.2	17.1	17.4	16.7
274	22-Nov-99	0.0	0.0	0.0	0.1	0.6	0.3	0.2	0.0	0.1	0.1	16.8	0.2	0.8	0.8	26.1	17.4	29.2	31.3	32.7	21.2	19.1	17.7	17.7
275	23-Nov-99	0.0	0.0	0.0	0.1	0.3	0.1	0.1	0.0	0.1	0.1	12.5	0.3	0.3	0.2	31.0	21.0	31.0	33.0	34.7	22.0	19.3	17.9	17.2
276	24-Nov-99	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	14.4	0.0	0.1	0.2	26.1	19.3	32.0	33.0	34.4	22.4	18.6	18.9	18.2
277	25-Nov-99	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	18.1	0.0	0.3	0.1	26.8	18.2	30.3	32.7	34.4	21.7	17.9	17.9	17.2
278	26-Nov-99	No Test - Exam																						
279	27-Nov-99	No Test - Exam																						
280	28-Nov-99	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.0	0.1	0.1	15.6	0.2	0.4	0.2	25.8	18.2	25.8	27.2	30.6	21.0	17.9	17.2	16.2
281	29-Nov-99	No Test - Stephanie Batch Test Yesterday (3l AN)																						
282	30-Nov-99	0.0	0.0	0.1	0.1	0.0	0.2	0.1	0.0	0.1	0.2	10.8	0.0	0.4	0.2	25.4	17.3	28.3	30.9	33.4	20.6	15.8	16.5	15.8
283	01-Dec-99	0.0	0.0	0.1	0.1	0.0	0.2	0.1	0.0	0.1	0.1	12.7	0.0	0.3	0.3	28.3	16.9	27.9	30.5	33.8	20.2	16.2	16.5	15.8
284	02-Dec-99	0.0	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.1	0.1	12.6	0.0	0.4	0.3	24.6	15.8	25.4	27.2	30.9	18.7	15.4	15.4	15.1
BATCH 20 Averages:		***0.0***	***0.0***	***0.0***	***0.1***	***0.2***	***0.2***	***0.1***	***0.0***	***0.1***	***0.1***	***14.7***	***0.1***	***0.4***	***0.5***	***27.0***	***17.9***	***28.8***	***30.8***	***33.1***	***20.9***	***17.5***	***17.3***	***16.7***

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
285	03-Dec-99	No Test - New Sewage Fed Yesterday																						
286	04-Dec-99	No Test - New Batch																						
287	05-Dec-99	0.0	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.1	0.1	14.3	0.0	0.3	0.2	26.1	14.7	26.1	27.6	30.9	18.4	14.3	13.2	12.9
288	06-Dec-99	0.0	0.0	0.0	0.1	0.3	0.3	0.1	0.0	0.1	0.1	12.1	0.1	0.5	0.2	23.5	14.0	25.4	26.8	30.1	17.3	13.6	14.0	13.2
289	07-Dec-99	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.2	11.4	0.1	0.5	0.5	23.7	16.4	25.5	27.2	30.0	19.2	15.0	15.0	14.7
290	08-Dec-99	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.1	12.8	0.1	0.8	0.6	24.4	17.8	27.2	29.0	31.4	24.1	17.4	16.4	16.0
291	09-Dec-99	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.1	14.8	0.1	0.8	0.5	26.9	17.8	28.6	29.0	31.7	25.5	17.1	16.7	16.4
292	10-Dec-99	No Test - Cleaned Unit Yesterday																						
293	11-Dec-99	No Test																						
294	12-Dec-99	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.1	0.1	0.1	12.8	0.1	0.5	0.4	24.4	16.7	27.6	29.0	31.7	25.5	15.7	17.1	16.7
295	13-Dec-99	0.0	0.0	0.0	0.5	0.0	0.1	0.1	0.0	0.1	0.2	11.9	0.1	0.9	0.6	24.7	15.1	25.4	27.1	31.6	25.7	14.4	14.8	14.4
296	14-Dec-99	No Test - New Sewage Fed Today																						
BATCH 21 Averages:		***0.0***	***0.0***	***0.0***	***0.1***	***0.1***	***0.1***	***0.1***	***0.0***	***0.1***	***0.1***	***12.9***	***0.1***	***0.6***	***0.4***	***24.8***	***16.1***	***26.5***	***27.9***	***31.1***	***22.2***	***15.4***	***15.3***	***14.9***
297	15-Dec-99	No Test - New Sewage																						
298	16-Dec-99	No Test - New Sewage																						
299	17-Dec-99	0.0	0.0	0.0	0.3	0.8	0.2	0.1	0.0	0.1	0.3	17.8	0.4	1.5	1.2	28.1	19.9	27.8	30.9	34.3	25.1	19.2	15.4	15.1
300	18-Dec-99	No Test																						
301	19-Dec-99	0.3	0.1	0.0	0.1	4.0	2.9	2.5	0.1	0.1	0.1	19.9	2.1	3.7	3.2	25.1	15.1	26.4	28.5	31.2	22.0	17.8	17.2	16.8
302	20-Dec-99	1.3	0.1	0.0	0.1	3.8	2.5	2.9	0.3	0.1	0.1	21.3	2.1	3.6	4.1	25.1	16.1	26.4	29.5	30.5	22.6	17.5	17.2	16.8
303	21-Dec-99	0.1	0.0	0.0	0.1	2.8	1.1	1.5	0.1	0.1	0.1	22.4	1.4	3.3	3.2	24.4	16.5	28.5	29.5	32.9	22.6	18.5	17.5	17.5
304	22-Dec-99	0.1	0.0	0.0	0.1	2.9	1.3	0.8	0.2	0.1	0.2	16.3	1.9	4.3	3.5	25.9	13.5	27.0	30.1	32.9	21.5	17.0	16.6	16.3
305	23-Dec-99	0.2	0.0	0.0	0.1	2.6	0.9	0.8	0.2	0.1	0.2	17.0	2.1	4.7	4.3	23.9	13.1	27.0	28.7	32.2	20.8	16.3	15.2	14.9
306	24-Dec-99	No Test																						
307	25-Dec-99	No Test																						
308	26-Dec-99	0.8	0.0	0.0	0.1	2.8	0.8	0.8	1.0	0.1	0.3	18.0	3.2	4.9	4.8	24.9	13.5	24.9	27.7	30.4	21.5	15.9	15.9	15.6
309	27-Dec-99	0.1	0.0	0.1	0.2	2.5	0.5	0.2	0.1	0.1	0.1	19.1	2.2	4.0	3.5	23.9	13.1	26.6	28.7	31.8	21.8	16.6	15.9	15.2
310	28-Dec-99	0.1	0.0	0.0	0.1	2.0	0.4	0.1	0.1	0.1	0.1	18.0	1.6	3.1	2.9	24.6	13.5	25.6	27.3	31.5	22.1	16.3	15.9	14.9
311	29-Dec-99	0.1	0.0	0.1	0.2	1.9	0.4	0.1	0.1	0.0	0.1	18.2	2.2	3.3	2.3	24.2	12.8	25.3	26.6	30.1	21.8	15.2	14.5	14.2
BATCH 22 Averages:		***0.3***	***0.0***	***0.0***	***0.1***	***2.6***	***1.1***	***1.0***	***0.2***	***0.1***	***0.2***	***18.8***	***1.9***	***3.7***	***3.3***	***25.0***	***14.7***	***26.6***	***28.8***	***31.8***	***22.2***	***17.0***	***16.1***	***15.7***
312	30-Dec-99	No Test - New Sewage Fed Today																						
313	31-Dec-99	No Test - New Sewage																						
314	01-Jan-00	No Test - New Sewage																						
315	02-Jan-00	1.2	0.0	0.0	0.2	1.1	1.6	1.2	11.4	0.2	0.2	30.8	13.0	15.4	16.3	24.3	15.2	20.9	22.4	24.7	20.2	17.1	16.8	15.8
316	03-Jan-00	1.0	0.0	0.0	0.2	0.7	1.4	1.1	11.2	0.2	0.2	33.6	11.7	15.3	15.9	23.1	16.4	18.6	20.2	24.3	19.6	18.3	17.7	17.1
317	04-Jan-00	0.4	0.0	0.0	0.2	0.7	0.6	0.6	1.1	0.1	0.2	24.5	2.5	6.3	12.4	22.8	15.8	25.3	27.5	30.3	21.2	17.7	17.4	17.1
318	05-Jan-00	0.2	0.0	0.1	0.1	1.2	0.6	0.2	0.3	0.1	0.1	26.1	1.6	5.0	4.5	22.8	16.4	27.5	29.1	29.7	21.8	18.0	18.0	17.4
319	06-Jan-00	0.5	0.0	0.0	0.2	1.5	0.7	0.3	0.7	0.1	0.1	23.8	2.4	5.5	4.6	21.5	15.5	25.3	27.2	28.1	19.6	17.4	17.4	17.1
320	07-Jan-00	0.6	0.0	0.0	0.2	0.8	0.7	0.4	4.0	0.1	0.1	24.8	5.3	8.0	6.0	21.8	14.5	26.6	26.9	27.5	19.3	16.1	16.1	16.1

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
321	08-Jan-00	No Test																						
322	09-Jan-00	No Test																						
323	10-Jan-00	0.1	0.0	0.1	0.6	1.1	0.4	0.2	0.3	0.1	0.2	15.1	0.6	2.2	2.5	24.3	17.3	27.7	29.2	30.7	22.2	18.3	18.6	18.3
324	11-Jan-00	0.3	0.0	0.1	0.5	1.5	0.6	0.3	0.5	0.1	0.1	16.7	1.5	3.5	3.1	24.0	16.1	27.1	28.3	28.9	21.3	18.0	18.6	18.3
325	12-Jan-00	0.8	0.0	0.1	0.2	1.7	1.1	0.6	1.9	0.1	0.1	18.1	4.2	4.9	3.4	23.7	15.8	24.6	24.6	28.3	21.9	18.3	19.2	18.9
326	13-Jan-00	1.3	0.1	0.0	0.2	2.1	1.6	0.8	3.8	0.1	0.2	19.6	5.8	6.5	6.3	23.7	16.4	22.2	23.7	26.8	20.7	17.6	18.3	18.3
327	14-Jan-00	0.1	0.0	0.1	0.2	2.2	0.5	0.3	0.3	0.1	0.1	20.5	1.1	3.1	4.4	24.6	10.3	23.1	24.3	27.4	18.0	11.9	12.2	12.2
BATCH 23 Averages:		***0.6***	***0.0***	***0.0***	***0.2***	***1.3***	***0.9***	***0.5***	***3.2***	***0.1***	***0.2***	***23.1***	***4.5***	***6.9***	***7.2***	***23.3***	***15.4***	***24.4***	***25.8***	***27.9***	***20.5***	***17.1***	***17.3***	***16.9***
328	15-Jan-00	No Test - New Sewage Fed Yesterday																						
329	16-Jan-00	0.1	0.0	0.0	0.1	1.3	0.3	0.1	0.3	0.1	0.1	12.7	2.2	3.4	2.5	21.2	10.7	19.6	21.2	23.9	16.0	13.2	12.0	12.0
330	17-Jan-00	0.3	0.0	0.0	0.1	1.0	0.4	0.2	0.8	0.1	0.1	13.2	2.6	4.0	3.5	22.1	12.0	19.3	20.6	23.3	16.6	13.5	12.9	12.6
331	18-Jan-00	1.0	0.0	0.0	0.1	1.8	1.3	0.4	4.5	0.1	0.2	22.6	6.7	8.0	4.9	25.8	13.5	23.6	25.8	30.4	20.9	16.0	14.1	13.8
332	19-Jan-00	0.0	0.0	0.1	0.1	1.0	0.4	0.3	0.2	0.1	0.2	22.6	0.7	4.1	2.9	26.4	16.9	31.3	34.0	36.2	24.5	17.8	15.3	15.0
333	20-Jan-00	0.8	0.1	0.1	0.1	2.3	1.0	0.5	1.8	0.1	0.1	16.5	3.9	5.5	3.9	25.8	15.6	27.3	30.4	34.0	24.2	18.4	18.1	17.5
334	21-Jan-00	1.1	0.1	0.0	0.1	2.0	1.0	0.8	4.0	0.1	0.1	20.4	4.2	6.9	5.3	26.4	15.0	23.0	24.5	29.1	22.1	16.9	16.9	16.3
335	22-Jan-00	No Test																						
336	23-Jan-00	No Test - Overflow from SET 2 fell off - emptied ANO into tray																						
337	24-Jan-00	0.9	0.1	0.0	0.0	2.8	0.9	1.7	3.2	0.1	0.2	17.7	7.8	8.6	12.3	24.5	14.2	25.8	28.6	32.1	21.4	16.7	16.7	16.0
338	25-Jan-00	0.8	0.1	0.0	0.0	2.8	0.8	0.6	2.3	0.1	0.2	22.1	7.6	7.9	7.2	24.8	13.8	26.4	29.9	34.3	22.0	16.4	15.7	15.4
339	26-Jan-00	0.7	0.0	0.1	0.0	2.4	0.5	0.5	3.1	0.1	0.1	28.1	10.7	9.3	7.9	26.4	15.1	27.7	30.8	34.9	23.0	17.3	17.0	16.7
340	27-Jan-00	Cleaned Unit - No Test																						
341	28-Jan-00	New Sewage Fed Today																						
BATCH 24 Averages:		***0.6***	***0.0***	***0.0***	***0.0***	***1.9***	***0.7***	***0.6***	***2.3***	***0.1***	***0.1***	***19.5***	***5.2***	***6.4***	***5.6***	***24.8***	***14.1***	***24.9***	***27.3***	***30.9***	***21.2***	***16.2***	***15.4***	***15.0***
342	29-Jan-00	No Test - New Sewage																						
343	30-Jan-00	No Test - New Sewage																						
344	31-Jan-00	0.1	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	0.1	13.1	0.0	1.3	1.8	24.8	16.0	28.0	31.1	32.4	22.6	17.3	16.4	16.4
345	01-Feb-00	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	17.9	0.1	1.5	1.3	28.3	17.3	32.1	34.3	37.1	25.5	17.6	17.0	16.7
346	02-Feb-00	No Test																						
347	03-Feb-00	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	19.7	0.1	0.6	0.7	31.8	23.6	37.1	39.9	42.5	30.2	20.1	20.1	19.8
348	04-Feb-00	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	6.7	0.1	0.2	0.5	33.2	24.8	35.7	38.9	42.3	31.7	21.6	21.0	21.0
349	05-Feb-00	No Test																						
350	06-Feb-00	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	7.0	0.1	0.9	0.6	26.6	19.7	31.0	32.9	36.0	25.4	17.9	18.8	18.5
351	07-Feb-00	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	7.4	0.1	1.0	0.9	32.0	21.6	36.4	36.7	39.8	27.6	19.1	19.1	18.8
352	08-Feb-00	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	8.6	0.2	0.5	0.6	30.7	21.6	35.4	37.0	39.5	29.8	19.1	19.7	19.4
353	09-Feb-00	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	10.2	0.2	0.6	0.4	32.0	23.8	37.6	39.5	42.3	30.4	20.4	20.1	20.7
354	10-Feb-00	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	10.6	0.3	0.7	0.4	28.5	20.1	35.1	37.6	40.4	29.2	17.2	19.1	19.1
355	11-Feb-00	New Sewage Fed Today																						
BATCH 25 Averages:		***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.1***	***0.1***	***0.0***	***0.0***	***0.1***	***11.2***	***0.1***	***0.8***	***0.8***	***29.8***	***21.0***	***34.3***	***36.4***	***39.2***	***28.0***	***18.9***	***19.0***	***18.9***

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
356	12-Feb-00	No Test - New Sewage																						
357	13-Feb-00	No Test - New Sewage																						
358	14-Feb-00	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.1	14.3	0.1	1.7	2.0	26.8	17.7	27.7	29.4	33.5	22.9	17.1	16.5	16.1
359	15-Feb-00	0.0	0.0	0.0	0.1	0.5	0.1	0.1	0.2	0.1	0.2	20.8	0.2	2.6	1.9	29.7	17.1	35.5	37.1	40.3	23.9	16.8	16.1	15.8
360	16-Feb-00	0.0	0.0	0.0	0.3	0.1	0.1	0.1	0.1	0.1	0.2	18.2	0.0	1.9	2.1	28.7	17.1	36.1	38.1	42.6	25.2	16.8	16.8	16.8
361	17-Feb-00	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	24.1	0.1	1.7	1.7	28.7	17.4	40.0	41.3	43.2	24.2	15.8	16.5	16.5
362	18-Feb-00	No Test - Stephanie Batch Test Yesterday (3l AN)																						
363	19-Feb-00	No Test - Nit/SET2 blocked up																						
364	20-Feb-00	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	21.8	0.0	2.2	1.8	26.5	14.5	34.5	38.1	38.4	22.3	12.6	11.9	11.9
365	21-Feb-00	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.1	12.8	0.0	0.9	0.7	32.6	15.2	37.5	40.6	43.4	23.6	13.7	12.4	12.1
366	22-Feb-00	0.0	0.0	0.1	0.8	0.0	0.1	0.1	0.0	0.0	0.1	16.5	0.0	0.8	0.8	28.5	16.8	38.2	40.0	41.6	23.3	14.6	16.1	15.5
367	23-Feb-00	0.1	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.0	0.1	16.4	0.0	0.7	0.7	35.4	18.3	41.3	44.7	45.3	26.4	16.8	16.1	16.1
368	24-Feb-00	0.0	0.1	0.0	0.1	0.2	0.1	0.2	0.0	0.0	0.0	16.6	0.0	0.7	0.5	32.0	23.0	40.0	42.5	44.7	29.5	21.7	19.9	19.5
BATCH 26 Averages:		***0.0***	***0.0***	***0.0***	***0.2***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***0.1***	***17.9***	***0.1***	***1.5***	***1.4***	***29.9***	***17.5***	***36.8***	***39.1***	***41.5***	***24.6***	***16.2***	***15.8***	***15.6***
369	25-Feb-00	New Sewage Fed Today																						
370	26-Feb-00	No Test - New Sewage																						
371	27-Feb-00	0.1	0.1	0.1	0.7	0.1	0.1	0.1	0.0	0.1	0.0	8.6	0.0	0.6	0.7	24.8	18.9	27.6	30.7	33.8	24.5	18.0	19.2	18.9
372	28-Feb-00	0.0	0.0	0.0	0.4	0.3	0.0	0.1	0.0	0.0	0.1	18.3	0.1	0.6	0.7	23.3	18.0	27.6	32.0	35.4	22.6	15.8	17.7	17.4
373	29-Feb-00	0.0	0.1	0.0	0.3	0.7	0.1	0.1	0.0	0.0	0.2	16.5	0.1	0.8	0.5	25.2	16.2	30.2	33.6	36.8	22.1	16.2	16.5	15.9
374	01-Mar-00	0.0	0.0	0.0	0.1	0.4	0.1	0.1	0.2	0.1	0.4	17.3	0.2	0.9	0.7	25.2	16.5	28.7	30.8	34.9	21.5	16.2	16.8	16.2
375	02-Mar-00	0.1	0.0	0.1	0.2	0.2	0.1	0.1	0.0	0.1	0.3	18.6	0.1	0.7	0.5	25.2	15.3	28.3	32.1	35.2	19.9	15.0	14.6	14.3
376	03-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)																						
377	04-Mar-00	No Test																						
378	05-Mar-00	0.0	0.1	0.0	0.3	0.2	0.1	0.2	0.0	0.1	0.1	18.9	0.0	0.6	0.5	26.2	17.1	31.2	32.7	36.4	21.2	16.2	16.8	16.2
379	06-Mar-00	0.0	0.0	0.0	0.2	0.3	0.1	0.1	0.0	0.0	0.2	17.1	0.1	0.8	0.7	25.0	15.4	30.0	32.7	36.1	21.6	16.4	14.8	14.8
380	07-Mar-00	0.0	0.0	0.0	0.1	1.2	0.0	0.1	-0.0	0.0	0.1	18.4	0.1	1.1	0.7	25.6	14.8	29.0	32.1	36.5	21.9	15.4	15.4	15.1
381	08-Mar-00	No Test (No Dist. Water)																						
382	09-Mar-00	New Sewage Fed Today																						
BATCH 27 Averages:		***0.0***	***0.0***	***0.0***	***0.3***	***0.4***	***0.1***	***0.1***	***0.0***	***0.1***	***0.2***	***16.7***	***0.1***	***0.8***	***0.6***	***25.1***	***16.5***	***29.1***	***32.1***	***35.6***	***21.9***	***16.1***	***16.5***	***16.1***
383	10-Mar-00	No Test - New Sewage																						
384	11-Mar-00	No Test - New Sewage																						
385	12-Mar-00	0.9	0.1	0.0	0.1	3.0	2.1	1.9	1.0	0.0	0.6	30.6	1.0	3.3	3.2	25.0	12.4	25.3	28.1	30.9	20.4	16.4	16.1	15.8
386	13-Mar-00	0.2	0.0	0.0	0.1	2.1	0.9	0.8	0.1	0.0	0.3	26.1	0.1	3.4	2.9	24.7	12.0	30.3	32.4	34.3	19.8	14.5	13.9	13.6
387	14-Mar-00	1.1	0.2	0.0	0.3	2.5	1.2	0.9	0.4	0.1	0.1	23.2	0.2	3.5	3.1	27.6	12.0	32.5	34.5	38.1	17.9	14.3	13.7	13.7
388	15-Mar-00	0.0	0.0	0.0	0.3	2.9	2.4	1.8	-0.0	0.1	0.1	27.6	0.2	0.9	2.7	24.7	12.4	30.6	32.5	35.5	18.9	13.3	13.7	13.7
389	16-Mar-00	0.3	0.1	0.0	0.1	3.0	1.7	2.6	0.0	0.1	0.1	27.3	0.5	-0.1	2.9	25.4	14.3	33.2	34.5	36.8	19.2	14.0	13.7	13.3
390	17-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)																						
391	18-Mar-00	No Test																						

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
392	19-Mar-00	1.2	0.0	0.0	0.1	2.7	1.0	1.3	1.5	0.0	0.1	26.7	1.7	4.7	4.8	25.0	15.6	28.9	30.6	34.2	21.8	17.2	17.2	16.9
393	20-Mar-00	0.7	0.3	0.0	0.0	1.3	0.7	0.6	2.8	0.3	0.3	26.3	4.0	6.7	5.7	27.2	15.4	28.2	30.7	35.5	22.4	17.9	17.9	17.3
394	21-Mar-00	0.6	0.0	0.0	0.0	0.8	0.7	0.6	3.6	0.1	0.3	30.2	5.1	8.3	7.8	24.6	14.7	28.2	30.4	33.9	21.4	17.0	17.0	16.6
395	22-Mar-00	0.3	0.0	0.1	0.0	0.5	0.3	0.3	2.4	0.1	0.4	28.0	4.6	8.0	7.7	25.3	15.0	29.1	31.0	35.2	22.1	17.9	16.3	16.0
396	23-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)																						
397	24-Mar-00	No Test - New Sewage fed yesterday																						
BATCH 28 Averages:		***0.6***	***0.1***	***0.0***	***0.1***	***2.1***	***1.2***	***1.2***	***1.3***	***0.1***	***0.3***	***27.3***	***1.9***	***4.3***	***4.5***	***25.5***	***13.8***	***29.6***	***31.6***	***34.9***	***20.4***	***15.8***	***15.5***	***15.2***
398	25-Mar-00	No Test - New Sewage																						
399	26-Mar-00	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.2	21.7	0.2	1.9	2.3	23.7	15.0	28.8	30.1	33.6	20.8	15.0	15.4	15.0
400	27-Mar-00	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.1	0.1	0.1	15.6	0.1	1.4	1.2	25.1	13.4	29.9	32.8	36.0	21.6	14.3	14.0	13.7
401	28-Mar-00	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	15.9	0.0	2.2	1.1	25.8	14.3	33.4	35.0	36.9	22.3	15.6	14.6	14.0
402	29-Mar-00	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	17.5	0.0	1.3	1.1	25.1	14.0	32.1	34.1	37.2	21.0	14.0	15.0	14.6
403	30-Mar-00	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	17.8	0.0	1.2	1.0	26.4	14.6	34.1	35.0	37.2	22.3	15.0	15.0	14.6
404	31-Mar-00	No Test																						
405	01-Apr-00	No Test																						
406	02-Apr-00	0.1	0.0	0.0	0.0	0.3	0.5	0.1	0.1	0.1	0.1	18.6	0.1	1.0	0.8	29.3	16.2	26.1	27.1	31.2	20.4	16.2	17.2	16.6
407	03-Apr-00	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.4	0.3	0.4	15.5	0.3	1.3	1.1	26.7	15.2	29.9	32.7	36.2	22.9	14.3	14.0	13.7
BATCH 29 Averages:		***0.0***	***0.0***	***0.0***	***0.0***	***0.1***	***0.2***	***0.1***	***0.1***	***0.1***	***0.1***	***17.5***	***0.1***	***1.5***	***1.2***	***26.0***	***14.7***	***30.6***	***32.4***	***35.5***	***21.6***	***14.9***	***15.0***	***14.6***
408	04-Apr-00	New Sewage Fed Yesterday, No Test																						
409	05-Apr-00	No Test - New Sewage																						
410	06-Apr-00	0.1	0.0	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.2	19.6	0.0	2.9	2.4	26.0	12.1	30.5	31.8	34.9	21.0	12.4	11.8	11.1
411	07-Apr-00	No Test																						
412	08-Apr-00	No Test																						
413	09-Apr-00	0.2	0.0	0.0	0.1	0.2	0.4	0.4	0.2	0.2	0.2	19.5	0.1	2.8	2.6	26.7	15.6	28.3	30.2	34.0	23.8	16.8	15.9	15.6
414	10-Apr-00	0.0	0.0	0.0	0.1	0.4	0.4	0.3	0.1	0.1	0.1	21.2	0.4	3.2	2.8	25.7	15.2	31.8	34.0	37.8	24.8	16.8	16.5	16.2
415	11-Apr-00	0.0	0.0	0.0	0.0	0.5	0.2	0.2	0.2	0.1	0.1	18.4	1.7	3.6	3.1	30.3	14.0	32.9	34.2	38.5	24.8	16.6	17.0	16.3
416	12-Apr-00	0.0	0.0	0.0	0.0	0.5	0.1	0.1	0.1	0.1	0.1	20.7	2.2	3.6	2.7	28.4	12.4	31.6	32.9	36.8	23.1	15.0	14.3	14.0
417	13-Apr-00	0.0	0.0	0.0	0.0	0.5	0.1	0.1	0.0	0.0	0.1	22.6	2.3	3.7	3.3	31.9	12.4	31.9	34.2	37.2	24.4	16.0	14.7	14.0
418	14-Apr-00	No Test																						
419	15-Apr-00	No Test																						
420	16-Apr-00	0.0	0.0	0.0	0.0	0.5	0.1	0.1	0.0	0.1	0.1	23.3	2.2	3.1	2.8	28.7	14.0	28.7	30.3	33.2	22.8	16.3	15.3	15.3
421	17-Apr-00	New Sewage fed today																						
BATCH 30 Averages:		***0.1***	***0.0***	***0.0***	***0.1***	***0.4***	***0.2***	***0.2***	***0.1***	***0.1***	***0.1***	***20.8***	***1.3***	***3.3***	***2.8***	***28.3***	***13.7***	***30.8***	***32.5***	***36.1***	***23.5***	***15.7***	***15.1***	***14.6***
422	18-Apr-00	Not Test - New Sewage (INCREASED INFLUENT TO 30 l YEST.)																						
423	19-Apr-00	No Test - New Sewage																						
424	20-Apr-00	Reduced influent to 25 l/d and Sludge Age to 8 days																						
425	21-Apr-00	No Test - Adapt to new config.																						
426	22-Apr-00	No Test - Adapt to new config.																						

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
427	23-Apr-00	No Test - Adapt to new config.																						
428	24-Apr-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	16.3	0.4	0.9	1.4	25.2	9.1	24.9	26.5	28.1	17.1	7.4	12.0	10.7
429	25-Apr-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	17.1	0.0	0.6	0.7	24.6	12.9	28.8	30.1	32.0	19.1	11.6	8.4	7.4
430	26-Apr-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	17.1	0.0	0.0	0.2	24.9	11.3	24.3	27.8	31.7	19.1	8.1	7.4	6.5
431	27-Apr-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	19.1	0.0	0.0	0.0	24.6	12.9	24.6	27.5	32.4	20.7	8.1	7.8	6.5
432	28-Apr-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	19.6	0.0	0.3	0.1	25.6	12.9	28.8	31.4	34.6	22.0	9.1	7.1	6.5
433	29-Apr-00	No Test																						
434	30-Apr-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	18.2	0.0	1.0	0.8	25.2	12.0	24.9	26.5	30.1	20.4	9.4	9.1	8.1
435	01-May-00	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	16.7	0.0	0.6	0.6	24.9	14.3	31.1	32.5	34.5	22.7	12.6	11.5	11.2
436	02-May-00	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.2	17.6	0.1	0.7	0.6	24.9	15.7	31.9	33.6	36.1	24.1	14.3	13.2	12.6
437	03-May-00	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	16.5	0.1	0.9	0.6	24.9	15.7	31.1	32.8	34.5	24.6	13.4	13.4	12.9
438	04-May-00	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-0.0	0.0	0.1	18.0	0.0	0.9	0.7	26.1	15.4	30.8	33.3	35.6	24.9	14.3	14.0	13.7
BATCH 31 Averages:		***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.1***	***17.8***	***0.1***	***0.6***	***0.6***	***25.1***	***13.2***	***28.1***	***30.2***	***33.0***	***21.5***	***10.8***	***10.4***	***9.6***
439	05-May-00	New Sewage Fed Yesterday, No Test																						
440	06-May-00	No Test - New Sewage																						
441	07-May-00	No Test - New Sewage																						
442	08-May-00	0.0	0.0	0.0	0.1	0.1	0.2	0.2	-0.0	0.0	0.1	22.3	0.0	1.4	0.6	25.8	13.7	36.7	38.7	40.6	25.2	12.6	11.8	11.2
443	09-May-00	0.0	0.1	0.4	0.1	1.7	0.7	0.4	0.0	0.1	-0.2	17.6	1.3	3.4	2.8	26.7	11.3	31.6	34.3	35.5	23.9	14.7	15.0	14.7
444	10-May-00	0.1	0.0	0.1	0.1	0.4	0.2	0.1	0.0	0.1	0.6	21.1	0.2	2.4	2.4	26.7	19.0	31.3	32.5	36.5	22.7	11.6	11.3	11.3
445	11-May-00	0.1	0.0	0.0	0.1	0.4	0.1	0.1	0.1	0.1	0.2	22.4	0.2	2.4	2.1	26.3	12.6	33.4	35.2	38.0	24.5	13.5	11.6	11.3
446	12-May-00	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.0	0.1	-0.0	23.6	0.1	2.0	2.1	27.6	13.5	32.5	34.0	37.7	23.9	12.9	12.6	12.6
447	13-May-00	No Test																						
448	14-May-00	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.4	25.2	0.1	2.6	2.1	26.7	19.0	37.1	38.9	42.3	30.0	18.4	17.5	16.9
449	15-May-00	0.1	0.0	0.0	0.1	1.1	0.3	0.1	0.1	0.1	0.1	24.1	2.5	4.6	2.6	27.0	12.6	33.4	35.8	37.7	25.7	16.5	16.9	16.9
450	16-May-00	No Test - No Distilled Water																						
451	17-May-00	0.0	0.0	0.0	0.0	1.2	0.1	0.1	0.1	0.0	0.1	26.2	2.3	4.5	5.3	25.7	11.0	27.9	29.5	31.4	21.0	13.5	14.7	14.1
452	18-May-00	0.0	0.0	0.0	0.0	1.2	0.3	0.1	0.1	0.1	0.1	25.0	3.5	5.6	3.9	25.1	12.6	27.3	29.8	32.6	22.9	15.7	14.1	13.8
453	19-May-00	No Test																						
454	20-May-00	No Test																						
455	21-May-00	0.0	0.0	0.0	0.5	1.0	0.5	0.2	0.3	0.1	0.2	29.7	1.6	3.8	5.4	25.1	15.4	28.9	28.9	32.3	21.3	14.1	15.7	15.1
456	22-May-00	Cleaned Unit																						
BATCH 32 Averages:		***0.0***	***0.0***	***0.1***	***0.1***	***0.7***	***0.2***	***0.2***	***0.1***	***0.1***	***0.2***	***23.7***	***1.2***	***3.3***	***2.9***	***26.3***	***14.1***	***32.0***	***33.8***	***36.5***	***24.1***	***14.4***	***14.1***	***13.8***
457	23-May-00	New Sewage Fed Today																						
458	24-May-00	WISA																						
459	25-May-00	WISA																						
460	26-May-00	WISA																						
461	27-May-00	WISA																						
462	28-May-00	WISA																						

		mgN/l														mgP/l								
		Nitrite							Nitrate							Phosphates								
Day No.	Date	PreANO	AN	SETA	SETB	ANO	AE	FE	PreANO	AN	SETA	SETB	ANO	AE	FE	UI	PreANO	AN	SETA	SETB	ANO	AE	UE	FE
463	29-May-00	WISA																						
464	30-May-00	WISA																						
465	31-May-00	WISA																						
466	01-Jun-00	WISA																						
467	02-Jun-00	WISA																						
468	03-Jun-00	WISA																						
469	04-Jun-00	Steering Committee																						
470	05-Jun-00	Research Seminar																						
BATCH 33 Averages:		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
471	06-Jun-00	New Sewage Fed																						
472	07-Jun-00	No Test - New Sewage																						
473	08-Jun-00	Reduce Sludge Age from 8 to 5 Days (install cont. waste)																						
474	09-Jun-00	No Test																						
475	10-Jun-00	No Test																						
476	11-Jun-00	0.5	0.0	0.0	0.0	0.2	1.0	0.4	12.7	0.3	0.1	30.7	16.8	18.4	17.8	28.6	16.1	23.6	25.2	28.3	22.3	19.2	18.3	17.3
477	12-Jun-00	0.3	0.0	0.0	0.0	0.2	0.9	0.6	11.5	0.2	0.2	32.8	15.9	17.3	19.0	26.4	15.1	25.8	28.0	30.8	23.6	18.6	19.5	17.6
478	13-Jun-00	0.3	0.0	0.0	0.0	0.2	0.8	0.6	8.3	0.1	0.2	33.7	13.0	14.1	17.0	24.9	14.2	27.1	28.3	30.2	22.3	17.3	18.9	17.3
479	14-Jun-00	0.5	0.0	0.0	0.0	0.3	1.0	0.5	8.6	0.2	0.2	31.9	13.1	14.4	15.8	26.4	14.2	23.6	25.5	28.3	22.0	17.0	18.6	16.7
480	15-Jun-00	1.0	0.0	0.0	0.0	0.3	1.3	0.8	11.3	0.2	0.2	37.7	14.5	14.8	15.7	25.5	14.8	23.3	25.2	27.7	22.0	17.9	18.9	17.3
481	16-Jun-00	1.2	0.0	0.0	0.0	0.3	1.5	1.2	11.1	0.2	0.2	39.1	16.3	15.4	16.1	25.5	15.4	23.3	25.2	26.8	21.4	18.9	18.9	17.3
482	17-Jun-00	No Test																						
483	18-Jun-00	1.4	0.0	0.0	0.0	0.6	1.8	1.5	13.1	0.2	0.1	38.1	15.0	17.0	17.4	24.9	17.3	19.8	21.1	23.9	21.4	18.9	19.5	18.3
BATCH 34 Averages:		***0.8***	***0.0***	***0.0***	***0.0***	***0.3***	***1.2***	***0.8***	***10.9***	***0.2***	***0.2***	***34.9***	***14.9***	***15.9***	***17.0***	***26.0***	***15.3***	***23.8***	***25.5***	***28.0***	***22.2***	***18.3***	***18.9***	***17.4***

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
1	22-Feb-99	4588.0	3088.0	1500.0	1980.0	1508.0	472.0	1.43	0.13	38.5	146.5	7.64	7.58
2	23-Feb-99	4478.0	3430.0	1048.0	2326.0	1822.0	504.0	1.34	0.08	34.6	124.7	7.55	7.47
3	24-Feb-99	3796.0	3010.0	786.0	2174.0	1626.0	548.0	1.31	0.14	38.4	128.8	Spoilt	Spoilt
4	25-Feb-99	3872.0	2952.0	920.0	2386.0	1838.0	548.0	1.45	-	26.3	125.7	7.54	7.52
5	26-Feb-99	No Test (SET 2 blocked up, sludge loss)											
6	27-Feb-99	No Test (AE, ANO & SET 2 overflowed, sludge loss)											
7	28-Feb-99	No Test (AE & SET 2 blocked, overflowed, sludge loss)											
8	01-Mar-99	6226.0	4690.0	1536.0	2074.0	1558.0	516.0	1.34	0.12	29.8	130.2	7.54	7.47
9	02-Mar-99	5122.0	3932.0	1190.0	1892.0	1474.0	418.0	1.30	0.09	25.8	126.8	7.39	7.42
10	03-Mar-99	1490.0	1148.0	342.0	1036.0	834.0	202.0	1.47	0.19	17.33	-	7.6	7.41
11	04-Mar-99	No Test (SmANO,ANO & AE overflowed, sludge loss) - New sewage fed today											
BATCH 1 Averages:		***4224.57***	***3176.57***	***1046.00***	***1981.14***	***1522.86***	***458.29***	***1.38***	***0.13***	***30.10***	***130.45***	***7.54***	***7.46***
12	05-Mar-99	No Test (New Sewage)											
13	06-Mar-99	No Test (New Sewage)											
14	07-Mar-99	No Test: SLUDGE FOUND IN SEWAGE - GET NEW BATCH											
15	08-Mar-99	No Test: -New Sewage Fed today											
BATCH 2 Averages:		***BAD BATCH***											
16	09-Mar-99	No Test (New Sewage)											
17	10-Mar-99	No Test (New Sewage)											
18	11-Mar-99	3610.0	3044.0	566.0	1372.0	1134.0	238.0	2.21	0.04	21.2	189.5	7.57	7.31
19	12-Mar-99	No Test											
20	13-Mar-99	No Test											
21	14-Mar-99	2690.0	2286.0	404.0	1508.0	1280.0	228.0	1.27	0.07	24.1	79.6	7.52	7.09
22	15-Mar-99	2542.0	2166.0	376.0	1406.0	1200.0	206.0	1.71	0.06	20.7	78.2	7.52	7.37
23	16-Mar-99	No Test (AN overflowed violently)											
24	17-Mar-99	2012.0	1764.0	248.0	1442.0	1288.0	154.0	1.27	-	23.7	83.2	7.41	7.11
25	18-Mar-99	1990.0	1704.0	286.0	1396.0	1212.0	184.0	1.52	0.06	23.1	78.8	7.56	7.36
BATCH 3 Averages:		***2568.8***	***2192.80***	***376.00***	***1424.80***	***1222.80***	***202.00***	***1.60***	***0.06***	***22.6***	***101.9***	***7.52***	***7.25***
26	19-Mar-99	No Test (New Sewage)											
27	20-Mar-99	No Test (New Sewage)											
28	21-Mar-99	No Test (SmANO,AN & AE overflowed - Sludge Loss)											
29	22-Mar-99	3290.0	2794.0	496.0	1436.0	1214.0	222.0	1.26	0.08	32	97.5	7.55	7.4
30	23-Mar-99	3288.0	2764.0	524.0	1374.0	1152.0	222.0	1.32	0.07	29.4	101.9	7.57	7.46
31	24-Mar-99	No Test (Install new freezer & spray SET1 black because of algae growth)											
32	25-Mar-99	3802.0	3166.0	636.0	1618.0	1364.0	254.0	1.43	0.09	34.6	86.5	7.54	7.42
33	26-Mar-99	No Test											
34	27-Mar-99	No Test											
35	28-Mar-99	2804.0	2358.0	446.0	1626.0	1388.0	238.0	1.44	0.09	33.56	98.4	7.6	7.48
36	29-Mar-99	3272.0	2778.0	494.0	1804.0	1530.0	274.0	1.17	-	41	99.8	7.64	7.49
37	30-Mar-99	No Test (Influent bucket run dry)											
38	31-Mar-99	No Test (Dregs of last sewage fed yesterday) - New sewage fed today											
BATCH 4 Averages:		***3291.20***	***2772.00***	***519.20***	***1571.60***	***1329.60***	***242.00***	***1.32***	***0.08***	***34.11***	***96.82***	***7.58***	***7.45***
39	01-Apr-99	No Test (New Sewage)											
40	02-Apr-99	No Test (New Sewage)											
41	03-Apr-99	No Test											
42	04-Apr-99	No Test (SmANO & Nitrifier overflowed - Sludge loss)											
43	05-Apr-99	3326.0	2762.0	564.0	1692.0	1430.0	262.0	1.31	0.09	28.9	112.3	7.55	7.51
44	06-Apr-99	No Test (Final settler failed - sludge in effluent)											
45	07-Apr-99	No Test (Final settler failed - sludge in effluent)											
46	08-Apr-99	No Test (Final settler failed - sludge in effluent)											
47	09-Apr-99	2242.0	1922.0	320.0	1422.0	1230.0	192.0	1.31	0.09	20.64	126.6	7.63	7.49
48	10-Apr-99	No Test (External Nitrifier overflowed - big sludge loss)											
49	11-Apr-99	2396.0	2022.0	374.0	1424.0	1204.0	220.0	1.32	0.10	27.9	119.4	7.52	7.51
50	12-Apr-99	2478.0	2140.0	338.0	1456.0	1290.0	166.0	1.27	0.09	22.5	116.8	7.62	7.59
51	13-Apr-99	3276.0	2760.0	516.0	1394.0	1212.0	182.0	1.25	0.09	27.7	107.6	7.42	7.36
52	14-Apr-99	Cleaned Unit											
53	15-Apr-99	2276.0	1904.0	372.0	1134.0	956.0	178.0	1.26	0.11	17	132.3	7.7	7.55
54	16-Apr-99	2532.0	2158.0	374.0	1144.0	986.0	158.0	1.36	0.13	15.9	131.1	7.62	7.61
BATCH 5 Averages:		***2646.57***	***2238.29***	***408.29***	***1380.86***	***1186.86***	***194.00***	***1.30***	***0.10***	***22.93***	***120.86***	***7.58***	***7.52***
55	17-Apr-99	No Test (New Sewage)											
56	18-Apr-99	No Test (New Sewage)											
57	19-Apr-99	2218.0	1820.0	398.0	1320.0	1082.0	238.0	1.54	0.08	25.3	136.4	7.61	7.59
58	20-Apr-99	No Test (AE & ANO overflowed - sludge loss)											
59	21-Apr-99	No Test (ANO & Nitrifier overflowed - sludge loss)											
60	22-Apr-99	2754.0	2326.0	428.0	1610.0	1394.0	216.0	1.47	0.09	28.6	124.2	7.64	7.62
61	23-Apr-99	No Test											
62	24-Apr-99	No Test											
63	25-Apr-99	No Test (ANO overflowed - sludge loss)											
64	26-Apr-99	No Test											
65	27-Apr-99	3474.0	2906.0	568.0	1676.0	1412.0	264.0	1.22	0.08	26.2	119.3	7.03	7.2
66	28-Apr-99	3242.0	2690.0	552.0	1646.0	1388.0	258.0	1.30	0.08	26.1	121.5	7.62	7.74
67	29-Apr-99	4012.0	3402.0	610.0	1824.0	1606.0	218.0	1.23	0.07	26.65	109.6	7.26	7.33

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
BATCH 6 Averages:		***3140.00***	***2628.80***	***511.20***	***1615.20***	***1376.40***	***238.80***	***1.35***	***0.08***	***26.57***	***122.21***	***7.43***	***7.50***
68	30-Apr-99	No Test (New Sewage)											
69	01-May-99	No Test (New Sewage)											
70	02-May-99	No Test (Nitrifier blocked, overlowing - sludge loss)											
71	03-May-99	3230.0	2652.0	578.0	1778.0	1458.0	320.0	1.22	0.08	20.6	123.7	7.64	7.62
72	04-May-99	3672.0	2984.0	688.0	1806.0	1510.0	296.0	1.22	0.08	18.1	110.7	7.63	7.5
73	05-May-99	3198.0	2546.0	652.0	1688.0	1360.0	328.0	1.32	0.10	19.5	118.5	7.6	7.56
74	06-May-99	2970.0	2342.0	628.0	1640.0	1328.0	312.0	1.34	0.09	20.5	122.0	7.64	7.59
75	07-May-99	3036.0	2348.0	688.0	1570.0	1212.0	358.0	1.34	0.09	21.1	127.4	7.6	7.52
76	08-May-99	No Test											
77	09-May-99	3178.0	2558.0	620.0	1772.0	1680.0	92.0	1.02	0.07	20.3	107.2	7.62	7.62
78	10-May-99	2776.0	2140.0	636.0	1670.0	1302.0	368.0	1.18	0.09	22	119.8	7.64	7.66
79	11-May-99	2412.0	1972.0	440.0	1588.0	1310.0	278.0	1.24	0.09	22.36	100.8	7.62	7.6
80	12-May-99	2416.0	1902.0	514.0	1514.0	1198.0	316.0	1.29	0.09	21.15	105.7	7.74	7.62
81	13-May-99	2574.0	1986.0	588.0	1536.0	1192.0	344.0	1.11	0.10	21.04	117.2	7.61	7.58
82	14-May-99	No Test (New Sewage Fed today)											
BATCH 7 Averages:		***2946.20***	***2343.00***	***603.20***	***1656.20***	***1355.00***	***301.20***	***1.23***	***0.09***	***20.67***	***115.29***	***7.63***	***7.59***
83	15-May-99	No Test (New Sewage)											
84	16-May-99	2606.0	2052.0	554.0	1346.0	1072.0	274.0	1.30	0.09	21.06	104.0	7.66	7.64
85	17-May-99	1908.0	1546.0	362.0	1258.0	1018.0	240.0	1.20	0.10	22.28	103.3	7.62	7.56
86	18-May-99	2756.0	2176.0	580.0	1238.0	1012.0	226.0	1.27	0.10	22	113.1	7.6	7.53
87	19-May-99	No Test (Batch Test 1 for Phosphates)											
88	20-May-99	No Test (Batch Test 1 for Phosphates)											
89	21-May-99	No Test											
90	22-May-99	No Test											
91	23-May-99	No Test (Batch Test 2 for Phosphates)											
92	24-May-99	2486.0	2080.0	406.0	1266.0	1100.0	166.0	1.45	0.12	18.89	110.6	7.45	7.72
93	25-May-99	1858.0	-	-	1248.0	986.0	262.0	1.24	0.12	19	104.2	7.45	7.7
94	26-May-99	2592.0	2160.0	432.0	1264.0	1114.0	150.0	1.00	0.08	20.09	110.8	7.46	7.72
95	27-May-99	1868.0	1514.0	354.0	1148.0	922.0	226.0	1.13	0.11	22.06	122.0	7.47	7.74
96	28-May-99	No Test											
97	29-May-99	No Test											
98	30-May-99	No Test (Dregs of last sewage fed yesterday) - New sewage fed today											
BATCH 8 Averages:		***2296.29***	***1921.33***	***448.00***	***1252.57***	***1032.00***	***220.57***	***1.23***	***0.10***	***20.77***	***109.70***	***7.53***	***7.66***
99	31-May-99	No Test (New Sewage)											
100	01-Jun-99	No Test (New Sewage)											
101	02-Jun-99	2090.0	1698.0	392.0	1086.0	880.0	206.0	1.37	0.11	19.73	92.1	7.54	7.82
102	03-Jun-99	No Test - Bad batch - Feed new sewage today											
BATCH 9 Averages:		***BAD BATCH***											
103	04-Jun-99	No Test (New Sewage)											
104	05-Jun-99	No Test (New Sewage)											
105	06-Jun-99	1640.0	1510.0	130.0	1028.0	912.0	116.0	1.44	0.10	22.8	126.5	7.64	7.85
106	07-Jun-99	1544.0	1294.0	250.0	978.0	834.0	144.0	1.33	0.12	24.32	102.2	7.6	7.83
107	08-Jun-99	1630.0	1378.0	252.0	1148.0	970.0	178.0	1.21	0.09	25.26	87.1	7.74	7.91
108	09-Jun-99	1778.0	1542.0	236.0	1120.0	946.0	174.0	1.39	0.10	25.23	107.1	7.51	7.63
109	10-Jun-99	No Test											
110	11-Jun-99	No Test - SmANO overflowed											
111	12-Jun-99	No Test											
112	13-Jun-99	Cleaned Unit											
113	14-Jun-99	No Test - (recouperate) - DO Probe & Box installed on Nitrifier											
114	15-Jun-99	No Test - Replace both DO boxes, re-install, service & calibrate probes											
115	16-Jun-99	2808.0	2296.0	512.0	1154.0	956.0	198.0	1.55	0.11	15.81	182.0	7.67	7.64
116	17-Jun-99	2644.0	2196.0	448.0	1216.0	1030.0	186.0	1.48	0.11	15.72	180.9	7.44	7.62
117	18-Jun-99	No Test											
118	19-Jun-99	No Test											
119	20-Jun-99	2206.0	1696.0	510.0	934.0	734.0	200.0	1.47	0.12	15.28	149.9	7.33	7.7
120	21-Jun-99	1500.0	1214.0	286.0	876.0	700.0	176.0	1.25	0.14	14.49	171.2	7.1	7.2
121	22-Jun-99	1418.0	1222.0	196.0	852.0	734.0	118.0	1.61	0.12	13.74	140.8	7.31	7.7
122	23-Jun-99	1028.0	938.0	90.0	698.0	664.0	34.0	1.29	0.11	12.48	143.3	7.31	7.44
123	24-Jun-99	No Test - Hydraulics Invidulation											
124	25-Jun-99	No Test -Exam											
125	26-Jun-99	No Test -Exam											
126	27-Jun-99	No Test -Exam											
127	28-Jun-99	2483.2	2278.0	205.2	1078.0	974.0	104.0	1.43	0.09	13.72	92.8	7.39	7.72
128	29-Jun-99	No Test											
129	30-Jun-99	1778.0	1482.0	296.0	972.0	830.0	142.0	1.37	0.10	11.01	102.9	7.44	7.73
130	01-Jul-99	2608.0	2044.0	564.0	864.0	686.0	178.0	1.44	0.12	12.75	115.7	7.39	7.72
131	02-Jul-99	2482.0	1954.0	528.0	916.0	732.0	184.0	1.45	0.11	12.5	109.2	7.36	7.71
132	03-Jul-99	No Test											
133	04-Jul-99	No Test (Stirrer on SET2 failed)											
134	05-Jul-99	No Test (Dregs of last sewage) - New Sewage fed today											
BATCH 10 Averages:		***1967.66***	***1646.00***	***321.66***	***988.14***	***835.86***	***152.29***	***1.41***	***0.11***	***16.79***	***129.40***	***7.45***	***7.69***

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
135	06-Jul-99	2810.0	2240.0	570.0	1434.0	1146.0	288.0	1.39	0.10	19.31	111.6	7.42	7.7
136	07-Jul-99	2632.0	2080.0	552.0	1436.0	1076.0	360.0	1.63	0.10	19.92	125.3	7.39	7.6
137	08-Jul-99	2740.0	2186.0	554.0	1488.0	1186.0	302.0	1.56	0.10	22.07	107.5	7.33	7.59
138	09-Jul-99	3612.0	2904.0	708.0	1416.0	1204.0	212.0	1.53	0.10	20.22	113.0	7.34	7.61
139	10-Jul-99	3144.0	2582.0	562.0	1494.0	1240.0	254.0	1.46	0.10	20.96	120.5	7.41	7.62
140	11-Jul-99	2964.0	2424.0	540.0	1462.0	1196.0	266.0	1.59	0.10	19.01	123.1	7.49	7.65
141	12-Jul-99	No Test											
142	13-Jul-99	2190.0	1780.0	410.0	1418.0	1154.0	264.0	1.72	0.10	19.2	119.9	7.29	7.59
143	14-Jul-99	2430.0	1972.0	458.0	1480.0	1208.0	272.0	1.46	0.10	19.04	101.4	-	-
144	15-Jul-99	3296.0	2668.0	628.0	1338.0	1088.0	250.0	1.60	0.11	24.64	134.5	-	-
145	16-Jul-99	Cleaned Unit											
146	17-Jul-99	No Test (Recouperate)											
147	18-Jul-99	2258.0	1802.0	456.0	1370.0	1086.0	284.0	1.75	0.11	26.13	116.8	7.75	7.61
148	19-Jul-99	2356.0	1876.0	480.0	1434.0	1156.0	278.0	1.53	0.10	25.24	118.5	7.57	7.4
149	20-Jul-99	No Test (Steering Commitee Meeting)											
150	21-Jul-99	2230.0	1984.0	246.0	1346.0	1264.0	82.0	1.37	0.09	32.5	126.3	7.39	7.35
151	22-Jul-99	2146.0	1734.0	412.0	1332.0	1068.0	264.0	1.45	0.10	16.69	135.1	7.52	7.03
152	23-Jul-99	No Test (New Sewage Fed Today)											
BATCH 11 Averages:		***2877.54***	***2171.69***	***505.85***	***1419.08***	***1159.38***	***259.69***	***1.54***	***0.10***	***21.92***	***119.51***	***6.30***	***6.37***
153	24-Jul-99	No Test (New Sewage)											
154	25-Jul-99	No Test (Electricity off)											
155	26-Jul-99	1906.0	1570.0	336.0	1334.0	1130.0	204.0	1.28	0.10	13.6	112.4	7.52	7.37
156	27-Jul-99	3054.0	2524.0	530.0	1342.0	1128.0	214.0	1.26	0.09	14.77	111.8	7.5	7.13
157	28-Jul-99	2844.0	2276.0	568.0	1488.0	1198.0	290.0	1.19	0.10	16.52	121.0	7.44	7.51
158	29-Jul-99	No Test (Nitrifier blocked up & overflowed violently)											
159	30-Jul-99	2834.0	2478.0	356.0	1594.0	1362.0	232.0	1.32	0.08	16.57	119.2	7.35	6.98
160	31-Jul-99	No Test											
161	01-Aug-99	No Test - Air off for 24 hours, entire system anoxic/anaerobic											
162	02-Aug-99	3260.0	2730.0	530.0	1424.0	1196.0	228.0	1.51	0.10	16.3	126.4	7.94	7.84
163	03-Aug-99	3280.0	2714.0	566.0	1614.0	1352.0	262.0	1.21	0.09	16.24	111.5	7.85	7.88
164	04-Aug-99	No Test - Power cut, DO boxes reset, no air											
165	05-Aug-99	2894.0	2436.0	458.0	1712.0	1440.0	272.0	1.20	0.09	18.3	116.8	7.54	7.55
166	06-Aug-99	3180.0	2672.0	508.0	1746.0	1480.0	266.0	1.25	0.08	16.2	114.5	7.43	7.17
BATCH 12 Averages:		***2906.50***	***2425.00***	***481.50***	***1531.75***	***1285.75***	***246.00***	***1.28***	***0.09***	***15.81***	***116.71***	***7.57***	***7.43***
167	07-Aug-99	No Test - New Sewage											
168	08-Aug-99	3482.0	3018.0	464.0	1774.0	1548.0	226.0	1.14	0.08	12.06	118.4	7.43	7.8
169	09-Aug-99	3142.0	2570.0	572.0	1668.0	1384.0	284.0	1.40	0.09	14.33	119.9	7.52	7.64
170	10-Aug-99	3334.0	2756.0	578.0	1598.0	1356.0	242.0	1.47	0.08	14.92	125.2	7.43	7.15
171	11-Aug-99	4212.0	3472.0	740.0	1428.0	1204.0	224.0	1.34	0.10	16.33	140.1	7.79	7.68
172	12-Aug-99	No Test - Cleaned Unit											
173	13-Aug-99	2930.0	2482.0	448.0	1244.0	1072.0	172.0	1.68	0.10	12.32	136.7	7.73	7.58
174	14-Aug-99	No Test											
175	15-Aug-99	2442.0	2018.0	424.0	1140.0	962.0	178.0	1.42	0.11	10.51	157.9	7.37	7.22
176	16-Aug-99	2568.0	2156.0	412.0	1204.0	1022.0	182.0	1.54	0.11	12.87	149.5	7.54	7.15
177	17-Aug-99	2464.0	2066.0	398.0	1292.0	1094.0	198.0	1.49	0.10	12.95	123.8	7.54	7.09
178	18-Aug-99	2728.0	2284.0	444.0	1256.0	1048.0	208.0	1.52	0.10	14.41	127.4	7.86	7.87
179	19-Aug-99	2430.0	2000.0	430.0	1200.0	986.0	214.0	1.76	0.11	13.41	133.3	7.88	8.12
180	20-Aug-99	2372.0	2010.0	362.0	1310.0	1120.0	190.0	1.47	0.09	13.52	122.1	8.2	8.3
181	21-Aug-99	No Test											
182	22-Aug-99	2628.0	2222.0	406.0	1450.0	1208.0	242.0	1.38	0.09	15.04	110.3	8	8.27
183	23-Aug-99	3056.0	2560.0	496.0	1580.0	1318.0	262.0	1.36	0.08	14.11	107.6	8.24	8.29
184	24-Aug-99	2254.0	1764.0	490.0	1388.0	1118.0	270.0	1.56	0.10	14.78	108.1	8.11	8.3
185	25-Aug-99	2516.0	2134.0	382.0	1350.0	1138.0	212.0	1.44	0.09	14.52	118.5	7.71	7.96
186	26-Aug-99	2914.0	2446.0	468.0	1358.0	1164.0	194.0	1.48	0.09	14.2	117.8	7.54	7.55
BATCH 13 Averages:		***2842.00***	***2372.37***	***469.63***	***1390.00***	***1171.36***	***218.63***	***1.47***	***0.09***	***13.77***	***126.04***	***7.74***	***7.75***
187	27-Aug-99	No Test (New Sewage)											
188	28-Aug-99	No Test (New Sewage)											
189	29-Aug-99	2738.0	2634.0	104.0	1446.0	1204.0	242.0	1.40	0.09	14.46	124.5	7.24	6.9
190	30-Aug-99	2686.0	2328.0	358.0	1314.0	1144.0	170.0	1.23	0.09	14.5	137.0	7.67	7.84
191	31-Aug-99	2088.0	1634.0	454.0	1518.0	1150.0	368.0	1.38	0.09	14.02	125.2	7.95	8.03
192	01-Sep-99	2064.0	1764.0	300.0	1494.0	1258.0	236.0	1.27	0.08	16.46	113.8	7.73	8.06
193	02-Sep-99	3398.0	2786.0	612.0	1376.0	1114.0	262.0	1.49	0.09	14.28	123.5	7.7	7.88
194	03-Sep-99	2030.0	1638.0	392.0	1440.0	1190.0	250.0	1.41	0.09	14	131.9	7.72	7.85
195	04-Sep-99	No Test (Changed Main ANO to 9l and Main AE to 4l)											
196	05-Sep-99	2934.0	2436.0	498.0	1230.0	1022.0	208.0	1.51	0.08	15.13	130.1	7.53	7.67
197	06-Sep-99	2242.0	1960.0	282.0	1284.0	1100.0	184.0	1.27	0.09	17.39	140.2	7.77	8.3
198	07-Sep-99	3462.0	2842.0	620.0	1304.0	1064.0	240.0	1.33	0.08	15.67	138.0	7.7	7.87
199	08-Sep-99	2520.0	2068.0	452.0	1282.0	1062.0	220.0	1.39	0.08	13.92	140.4	7.59	7.52
200	09-Sep-99	2620.0	2160.0	460.0	1142.0	956.0	186.0	1.40	0.10	13.47	148.9	7.73	7.56
201	10-Sep-99	2850.0	2344.0	506.0	1240.0	1034.0	206.0	1.38	0.08	12.02	129.0	7.75	7.58
202	11-Sep-99	No Test											
203	12-Sep-99	No Test - Dregs of sewage batch											

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
BATCH 14 Averages:		2636.00	2216.17	419.83	1339.17	1108.17	231.00	1.37	0.09	14.61	131.88	7.67	7.76
204	13-Sep-99	No Test - New Sewage											
205	14-Sep-99	No Test - New Sewage											
206	15-Sep-99	No Test - AN overflowed											
207	16-Sep-99	2316.0	1896.0	420.0	1096.0	902.0	194.0	1.27	0.11	13.2	164.2	7.61	7.18
208	17-Sep-99	No Test											
209	18-Sep-99	No Test											
210	19-Sep-99	2210.0	1784.0	426.0	1090.0	904.0	186.0	1.41	0.11	14.01	146.8	7.98	8.16
211	20-Sep-99	2386.0	1950.0	436.0	1234.0	1016.0	218.0	1.40	0.10	14.23	154.0	7.91	7.93
212	21-Sep-99	2398.0	1946.0	452.0	1228.0	1012.0	216.0	1.51	0.10	14.72	146.6	7.9	7.89
213	22-Sep-99	2266.0	1866.0	400.0	1130.0	948.0	182.0	1.50	0.10	15.05	159.3	7.84	7.87
214	23-Sep-99	No Test - Electricity off											
215	24-Sep-99	No Test											
216	25-Sep-99	No Test											
BATCH 15 Averages:		2315.20	1888.40	426.80	1155.60	956.40	199.20	1.42	0.10	14.24	154.17	7.85	7.81
217	26-Sep-99	New Sewage											
218	27-Sep-99	No Test - New Batch											
219	28-Sep-99	2854.0	2360.0	494.0	1368.0	1142.0	226.0	1.41	0.10	14.89	131.6	7.56	7.75
220	29-Sep-99	2640.0	2162.0	478.0	1342.0	1098.0	244.0	1.49	0.11	18.83	134.1	7.5	7.77
221	30-Sep-99	3180.0	2642.0	538.0	1538.0	1274.0	264.0	1.46	0.10	18.83	117.0	7.48	7.82
222	01-Oct-99	2880.0	2418.0	462.0	1644.0	1370.0	274.0	1.43	0.09	20.78	109.5	7.52	7.86
223	02-Oct-99	No Test											
224	03-Oct-99	2984.0	2438.0	546.0	1746.0	1420.0	326.0	1.42	0.09	22.94	108.8	7.8	8
225	04-Oct-99	3370.0	2754.0	616.0	1798.0	1496.0	302.0	1.48	0.09	22.04	105.7	7.57	7.93
226	05-Oct-99	3270.0	2672.0	598.0	1730.0	1454.0	276.0	1.48	0.09	21.14	104.0	7.81	8.08
227	06-Oct-99	3138.0	2594.0	544.0	1678.0	1378.0	300.0	1.51	0.09	21	107.3	7.67	8.1
228	07-Oct-99	3348.0	2706.0	642.0	1708.0	1352.0	356.0	1.53	0.09	20.98	105.4	7.57	7.96
229	08-Oct-99	2776.0	2276.0	500.0	1734.0	1418.0	316.0	1.45	0.10	21.96	103.8	7.72	7.96
230	09-Oct-99	No Test											
231	10-Oct-99	SET 2 overflowed - No Test											
BATCH 16 Averages:		3044.00	2502.20	541.80	1628.60	1340.20	288.40	1.47	0.10	20.34	112.72	7.62	7.92
232	11-Oct-99	New Sewage											
233	12-Oct-99	No Test - New Batch											
234	13-Oct-99	4216.0	3418.0	798.0	1780.0	1466.0	314.0	1.58	0.10	20.73	106.7	7.67	8.14
235	14-Oct-99	3470.0	2814.0	656.0	1668.0	1388.0	280.0	1.60	0.09	25.24	107.9	7.56	7.9
236	15-Oct-99	4558.0	3652.0	906.0	1738.0	1406.0	332.0	1.61	0.10	21.56	103.6	7.9	8.01
237	16-Oct-99	No Test											
238	17-Oct-99	3434.0	2784.0	650.0	1836.0	1572.0	264.0	1.47	0.09	22.47	92.6	7.6	7.77
239	18-Oct-99	No Test (Stephanie Batch Test - 3l from AN)											
240	19-Oct-99	3336.0	2772.0	564.0	1464.0	1272.0	192.0	1.31	0.10	23.71	109.3	7.57	7.8
241	20-Oct-99	2898.0	2632.0	266.0	1420.0	1160.0	260.0	1.59	0.10	25.97	98.6	7.83	8.06
242	21-Oct-99	2658.0	2196.0	462.0	1524.0	1278.0	246.0	1.37	0.10	24.62	91.9	8.04	8.1
243	22-Oct-99	2386.0	1916.0	470.0	1684.0	1362.0	322.0	1.39	0.10	23.37	95.0	8.11	8.15
244	23-Oct-99	No Test											
245	24-Oct-99	3222.0	2666.0	556.0	1522.0	1292.0	230.0	1.38	0.11	22.52	85.4	7.96	7.93
BATCH 17 Averages:		3353.11	2761.11	592.00	1626.22	1355.11	271.11	1.48	0.10	23.35	99.00	7.80	7.98
246	25-Oct-99	New Sewage Fed Today, Cleaned Unit, 3l AN for Stephanie											
247	26-Oct-99	No Test - New Batch											
248	27-Oct-99	No Test - New Batch											
249	28-Oct-99	3074.0	2524.0	550.0	1406.0	1166.0	240.0	1.32	0.09	12.95	106.7	7.54	7.96
250	29-Oct-99	2484.0	2046.0	438.0	1322.0	1116.0	206.0	1.43	0.10	12.33	90.8	7.6	7.99
251	30-Oct-99	No Test											
252	31-Oct-99	2324.0	1960.0	364.0	1282.0	1180.0	102.0	1.33	0.10	14.5	93.6	7.72	8.05
253	01-Nov-99	2500.0	2120.0	380.0	1332.0	1160.0	172.0	1.32	0.10	16.9	90.1	7.73	8.02
254	02-Nov-99	3810.0	3122.0	688.0	1670.0	1390.0	280.0	1.54	0.10	23.04	83.8	7.64	8.06
255	03-Nov-99	3132.0	2594.0	538.0	1820.0	1512.0	308.0	1.52	0.09	22.39	71.4	7.79	8.14
256	04-Nov-99	3058.0	2546.0	512.0	1600.0	1408.0	192.0	1.48	0.10	22.84	87.5	7.65	8.05
257	05-Nov-99	No Test - Nitrifier Overflowed											
258	06-Nov-99	No Test											
259	07-Nov-99	4150.0	3372.0	778.0	1944.0	1590.0	354.0	1.42	0.10	17.54	77.2	7.76	8.07
BATCH 18 Averages:		***3066.50***	***2535.50***	***531.00***	***1547.00***	***1315.25***	***231.75***	***1.42***	***0.10***	***17.61***	***87.63***	***7.68***	***8.04***
260	08-Nov-99	New Sewage Fed Today											
261	09-Nov-99	No Test - New Batch											
262	10-Nov-99	No Test - New Batch											
263	11-Nov-99	3356.0	2752.0	604.0	1692.0	1420.0	272.0	1.37	0.10	17.82	82.7	7.79	7.99
264	12-Nov-99	2916.0	2386.0	530.0	1808.0	1498.0	310.0	1.44	0.09	18.51	77.4	7.94	8.15
265	13-Nov-99	No Test											
266	14-Nov-99	2894.0	2364.0	530.0	1554.0	1282.0	272.0	1.69	0.11	17.15	90.1	7.49	7.6
267	15-Nov-99	2906.0	2382.0	524.0	1498.0	1236.0	262.0	1.52	0.11	18.13	93.5	7.6	7.58
268	16-Nov-99	No Test - Stephanie Batch Test Yesterday (3l AN)											
269	17-Nov-99	2850.0	2356.0	494.0	1796.0	1498.0	298.0	1.49	0.10	19.11	83.5	7.59	7.58
270	18-Nov-99	3100.0	2550.0	550.0	1744.0	1526.0	218.0	1.36	0.10	18.03	91.7	7.74	7.78

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
271	19-Nov-99	2826.0	2360.0	466.0	1804.0	1516.0	288.0	1.37	0.10	18.38	83.1	7.75	7.77
BATCH 19 Averages:		***2978.29***	***2450.00***	***528.29***	***1699.43***	***1425.14***	***274.29***	***1.46***	***0.10***	***18.16***	***86.02***	***7.70***	***7.78***
272	20-Nov-99	No Test - New Batch											
273	21-Nov-99	3154.0	2620.0	534.0	1702.0	1454.0	248.0	1.24	0.09	18.76	94.0	7.51	7.88
274	22-Nov-99	3148.0	2618.0	530.0	1960.0	1628.0	332.0	1.48	0.09	18.77	81.6	7.62	8.07
275	23-Nov-99	3632.0	2982.0	650.0	1574.0	1298.0	276.0	1.46	0.11	17.92	101.7	7.55	7.91
276	24-Nov-99	3200.0	2658.0	542.0	1760.0	1480.0	280.0	1.46	0.10	19.83	90.9	7.47	7.87
277	25-Nov-99	3190.0	2610.0	580.0	1826.0	1528.0	298.0	1.53	0.10	20.73	98.6	7.76	8.14
278	26-Nov-99	No Test - Exam											
279	27-Nov-99	No Test - Exam											
280	28-Nov-99	4510.0	3744.0	766.0	1952.0	1682.0	270.0	1.29	0.09	18.95	92.2	7.65	7.99
281	29-Nov-99	No Test - Stephanie Batch Test Yesterday (3l AN)											
282	30-Nov-99	4164.0	3428.0	736.0	1946.0	1674.0	272.0	1.42	0.09	19.45	92.5	7.86	8.17
283	01-Dec-99	3846.0	3106.0	740.0	1922.0	1556.0	366.0	1.51	0.10	19.94	93.7	7.75	8.16
284	02-Dec-99	3748.0	3070.0	678.0	1960.0	1638.0	322.0	1.45	0.09	20.67	81.6	7.68	8.05
BATCH 20 Averages:		***3621.33***	***2981.78***	***639.56***	***1844.67***	***1548.67***	***296.00***	***1.43***	***0.10***	***19.45***	***91.88***	***7.65***	***8.03***
285	03-Dec-99	No Test - New Sewage Fed Yesterday											
286	04-Dec-99	No Test - New Batch											
287	05-Dec-99	3346.0	2694.0	652.0	1818.0	1470.0	348.0	1.48	0.10	18.99	77.0	7.65	8.05
288	06-Dec-99	3700.0	3000.0	700.0	1942.0	1608.0	334.0	1.39	0.09	18.48	82.4	7.6	8.09
289	07-Dec-99	3586.0	2878.0	708.0	1810.0	1462.0	348.0	1.40	0.08	17.71	93.9	7.61	8.09
290	08-Dec-99	4304.0	3450.0	854.0	2034.0	1642.0	392.0	1.44	0.08	18.11	78.7	7.6	8
291	09-Dec-99	4058.0	3326.0	732.0	1916.0	1568.0	348.0	1.52	0.08	18.82	93.9	7.53	7.84
292	10-Dec-99	No Test - Cleaned Unit Yesterday											
293	11-Dec-99	No Test											
294	12-Dec-99	3898.0	3180.0	718.0	1870.0	1582.0	288.0	1.50	0.09	19.31	96.3	7.65	8.15
295	13-Dec-99	3834.0	3062.0	772.0	1890.0	1532.0	358.0	1.58	0.11	19.92	95.2	7.66	8.14
296	14-Dec-99	No Test - New Sewage Fed Today											
BATCH 21 Averages:		***3818.00***	***3084.29***	***733.71***	***1897.14***	***1552.00***	***345.14***	***1.47***	***0.09***	***18.76***	***88.20***	***7.61***	***8.05***
297	15-Dec-99	No Test - New Sewage											
298	16-Dec-99	No Test - New Sewage											
299	17-Dec-99	3084.0	2478.0	606.0	2154.0	1730.0	424.0	1.47	0.10	18.49	83.6	7.22	7.23
300	18-Dec-99	No Test											
301	19-Dec-99	3812.0	3032.0	780.0	1854.0	1482.0	372.0	1.38	0.10	17.54	97.1	7.59	7.71
302	20-Dec-99	4010.0	3190.0	820.0	1952.0	1582.0	370.0	1.34	0.09	15.12	82.0	7.39	7.56
303	21-Dec-99	3458.0	2794.0	664.0	1750.0	1422.0	328.0	1.59	0.10	16.51	97.1	7.19	7.26
304	22-Dec-99	3308.0	2738.0	570.0	1778.0	1554.0	224.0	1.40	0.09	17.65	95.6	7.44	7.57
305	23-Dec-99	3730.0	2972.0	758.0	1742.0	1416.0	326.0	1.38	0.10	17.27	103.3	7.55	7.83
306	24-Dec-99	No Test											
307	25-Dec-99	No Test											
308	26-Dec-99	3086.0	2498.0	588.0	1656.0	1410.0	246.0	1.28	0.09	15.49	84.5	7.67	7.98
309	27-Dec-99	3702.0	2922.0	780.0	1578.0	1250.0	328.0	1.54	0.11	16.53	101.4	7.52	7.91
310	28-Dec-99	2444.0	2004.0	440.0	1708.0	1498.0	210.0	1.30	0.09	17.56	93.7	7.68	7.93
311	29-Dec-99	3124.0	2648.0	476.0	1696.0	1540.0	156.0	1.47	0.09	18.01	100.2	7.79	8.03
BATCH 22 Averages:		***3375.80***	***2727.60***	***648.20***	***1766.80***	***1488.40***	***298.40***	***1.41***	***0.10***	***17.02***	***93.86***	***7.50***	***7.70***
312	30-Dec-99	No Test - New Sewage Fed Today											
313	31-Dec-99	No Test - New Sewage											
314	01-Jan-00	No Test - New Sewage											
315	02-Jan-00	3280.0	2604.0	676.0	1684.0	1354.0	330.0	1.47	0.11	18.06	77.2	8	7.97
316	03-Jan-00	2674.0	2166.0	508.0	1530.0	1254.0	276.0	1.29	0.11	17.84	91.5	7.89	7.81
317	04-Jan-00	2702.0	2192.0	510.0	1460.0	1200.0	260.0	1.44	0.10	18.12	95.9	7.66	7.82
318	05-Jan-00	2596.0	2138.0	458.0	1420.0	1194.0	226.0	1.37	0.11	17.28	98.6	7.59	7.82
319	06-Jan-00	2372.0	1986.0	386.0	1232.0	1100.0	132.0	1.31	0.11	16.78	113.6	7.6	7.78
320	07-Jan-00	2364.0	1934.0	430.0	1292.0	1084.0	208.0	1.40	0.12	15.5	108.4	7.62	7.8
321	08-Jan-00	No Test											
322	09-Jan-00	No Test											
323	10-Jan-00	2364.0	1958.0	406.0	1262.0	1086.0	176.0	1.30	0.11	16.2	95.1	7.52	7.74
324	11-Jan-00	2078.0	1714.0	364.0	1200.0	1004.0	196.0	1.51	0.12	17	100.0	7.65	7.84
325	12-Jan-00	1966.0	1662.0	304.0	1148.0	1034.0	114.0	1.38	0.11	15.25	104.5	7.72	7.91
326	13-Jan-00	1848.0	1556.0	292.0	1148.0	970.0	178.0	1.49	0.12	14.4	104.5	7.81	7.95
327	14-Jan-00	3246.0	2650.0	596.0	1940.0	1614.0	326.0	1.44	0.09	20.51	92.8	7.7	8.04
BATCH 23 Averages:		***2499.09***	***2050.91***	***448.18***	***1392.36***	***1172.18***	***220.18***	***1.40***	***0.11***	***16.99***	***98.37***	***7.71***	***7.86***
328	15-Jan-00	No Test - New Sewage Fed Yesterday											
329	16-Jan-00	4110.0	3366.0	744.0	1920.0	1612.0	308.0	1.39	0.09	16.86	88.5	7.37	7.67
330	17-Jan-00	3112.0	2502.0	610.0	1802.0	1450.0	352.0	1.57	0.10	18.09	99.9	7.63	7.7
331	18-Jan-00	3724.0	3038.0	686.0	1976.0	1642.0	334.0	1.30	0.10	20.33	91.1	7.76	7.74
332	19-Jan-00	3476.0	2810.0	666.0	1892.0	1556.0	336.0	1.32	0.10	30.98	84.6	7.45	7.75
333	20-Jan-00	3122.0	2564.0	558.0	1846.0	1558.0	288.0	1.34	0.10	28.47	102.9	7.79	7.95
334	21-Jan-00	3214.0	2566.0	648.0	1734.0	1414.0	320.0	1.48	0.10	22.81	115.3	7.91	7.96
335	22-Jan-00	No Test											
336	23-Jan-00	No Test - Overflow from SET 2 fell off - emptied ANO into tray											
337	24-Jan-00	3504.0	2812.0	692.0	1790.0	1466.0	324.0	1.40	0.10	24.38	100.6	7.86	8.04

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
338	25-Jan-00	3510.0	2812.0	698.0	1822.0	1482.0	340.0	1.45	0.10	22.51	115.3	7.85	8.02
339	26-Jan-00	3306.0	2706.0	600.0	1730.0	1446.0	284.0	1.24	0.10	20.5	115.6	7.84	8.04
340	27-Jan-00	Cleaned Unit - No Test											
341	28-Jan-00	New Sewage Fed Today											
BATCH 24 Averages:		***3453.11***	***2797.33***	***655.78***	***1834.67***	***1514.00***	***320.67***	***1.39***	***0.10***	***22.77***	***101.53***	***7.72***	***7.87***
342	29-Jan-00	No Test - New Sewage											
343	30-Jan-00	No Test - New Sewage											
344	31-Jan-00	3402.0	2790.0	612.0	1716.0	1464.0	252.0	1.41	0.10	16.38	116.6	7.7	8.13
345	01-Feb-00	3064.0	2568.0	516.0	1866.0	1568.0	298.0	1.32	0.09	17.41	112.5	7.66	8.16
346	02-Feb-00	No Test											
347	03-Feb-00	3160.0	2580.0	580.0	1808.0	1460.0	348.0	1.48	0.10	18.96	110.6	7.54	7.99
348	04-Feb-00	3064.0	2576.0	488.0	2078.0	1734.0	344.0	1.09	0.09	19.95	101.1	7.55	8.05
349	05-Feb-00	No Test											
350	06-Feb-00	4108.0	3364.0	744.0	2006.0	1660.0	346.0	1.45	0.09	18.38	89.7	7.65	8.09
351	07-Feb-00	3740.0	3108.0	632.0	1994.0	1658.0	336.0	1.47	0.10	19.7	110.3	7.61	8.08
352	08-Feb-00	3554.0	2886.0	668.0	2100.0	1704.0	396.0	1.53	0.09	19.89	95.2	7.51	7.95
353	09-Feb-00	3542.0	2942.0	600.0	1996.0	1664.0	332.0	1.46	0.10	21.45	110.2	7.54	7.96
354	10-Feb-00	3386.0	2758.0	628.0	1888.0	1558.0	330.0	1.51	0.10	24.44	111.2	7.4	7.87
355	11-Feb-00	New Sewage Fed Today											
BATCH 25 Averages:		***3448.89***	***2841.33***	***607.56***	***1939.11***	***1607.78***	***331.33***	***1.41***	***0.10***	***19.82***	***106.39***	***7.57***	***8.03***
356	12-Feb-00	No Test - New Sewage											
357	13-Feb-00	No Test - New Sewage											
358	14-Feb-00	2894.0	2362.0	532.0	2220.0	1802.0	418.0	1.30	0.09	17.24	94.6	7.59	7.95
359	15-Feb-00	4630.0	3744.0	886.0	2114.0	1750.0	364.0	1.35	0.10	18.81	89.9	7.55	8
360	16-Feb-00	3624.0	2950.0	674.0	2002.0	1640.0	362.0	1.36	0.10	18.31	99.9	7.52	8.01
361	17-Feb-00	3610.0	2932.0	678.0	1938.0	1602.0	336.0	1.33	0.10	19.29	113.5	7.45	8.03
362	18-Feb-00	No Test - Stephanie Batch Test Yesterday (3l AN)											
363	19-Feb-00	No Test - Nit/SET2 blocked up											
364	20-Feb-00	4340.0	3574.0	766.0	2070.0	1720.0	350.0	1.37	0.10	20.69	91.8	7.59	8.06
365	21-Feb-00	4448.0	3660.0	788.0	2258.0	1880.0	378.0	1.38	0.10	21.1	97.4	7.48	8.05
366	22-Feb-00	4474.0	3660.0	814.0	2328.0	1826.0	502.0	1.46	0.10	22.1	103.1	7.47	7.99
367	23-Feb-00	3986.0	3224.0	762.0	2178.0	1760.0	418.0	1.43	0.10	20.68	82.6	7.48	7.97
368	24-Feb-00	4406.0	3760.0	646.0	2274.0	2014.0	260.0	1.38	0.09	21.26	79.2	7.56	8.2
BATCH 26 Averages:		***4045.78***	***3318.44***	***727.33***	***2153.56***	***1777.11***	***376.44***	***1.37***	***0.10***	***19.84***	***94.67***	***7.52***	***8.03***
369	25-Feb-00	New Sewage Fed Today											
370	26-Feb-00	No Test - New Sewage											
371	27-Feb-00	3560.0	2900.0	660.0	1918.0	1590.0	328.0	1.47	0.08	17.04	99.1	7.8	8.31
372	28-Feb-00	3778.0	3136.0	642.0	1990.0	1682.0	308.0	1.41	0.08	17.63	90.5	7.73	8.16
373	29-Feb-00	2914.0	2370.0	544.0	2568.0	2042.0	526.0	1.48	0.09	18.05	77.9	7.71	8.17
374	01-Mar-00	3524.0	2980.0	544.0	2112.0	1808.0	304.0	1.32	0.09	16.38	94.7	7.68	8.07
375	02-Mar-00	3242.0	2650.0	592.0	2342.0	1948.0	394.0	1.41	0.09	14.58	102.5	7.64	8.16
376	03-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)											
377	04-Mar-00	No Test											
378	05-Mar-00	4346.0	3506.0	840.0	2746.0	2180.0	566.0	1.41	0.08	14.05	72.8	7.39	8.04
379	06-Mar-00	3120.0	2556.0	564.0	2340.0	1906.0	434.0	1.58	0.09	14.43	85.5	7.65	8
380	07-Mar-00	2898.0	2330.0	568.0	2012.0	1596.0	416.0	1.56	0.10	16.51	89.5	7.62	8.06
381	08-Mar-00	No Test (No Dist. Water)											
382	09-Mar-00	New Sewage Fed Today											
BATCH 27 Averages:		***3422.75***	***2803.50***	***619.25***	***2253.50***	***1844.00***	***409.50***	***1.45***	***0.09***	***16.08***	***89.04***	***7.65***	***8.12***
383	10-Mar-00	No Test - New Sewage											
384	11-Mar-00	No Test - New Sewage											
385	12-Mar-00	3366.0	2750.0	616.0	1690.0	1432.0	258.0	1.42	0.10	15.59	106.5	7.8	8.15
386	13-Mar-00	3264.0	2654.0	610.0	2130.0	1742.0	388.0	1.44	0.08	19.04	93.9	7.56	7.96
387	14-Mar-00	3024.0	2518.0	506.0	2042.0	1816.0	226.0	1.49	0.07	17.85	93.0	7.58	7.86
388	15-Mar-00	3082.0	2548.0	534.0	1992.0	1630.0	362.0	1.45	0.07	15.69	90.4	7.46	7.8
389	16-Mar-00	2850.0	2312.0	538.0	2060.0	1654.0	406.0	1.39	0.09	15.33	106.8	7.49	7.97
390	17-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)											
391	18-Mar-00	No Test											
392	19-Mar-00	2792.0	2266.0	526.0	2208.0	1784.0	424.0	1.49	0.09	18.43	81.5	7.61	7.79
393	20-Mar-00	3140.0	2548.0	592.0	2132.0	1722.0	410.0	1.45	0.10	19.57	89.1	7.62	7.83
394	21-Mar-00	3292.0	2672.0	620.0	2076.0	1688.0	388.0	1.41	0.10	19.96	91.5	7.58	7.74
395	22-Mar-00	3876.0	3110.0	766.0	1976.0	1628.0	348.0	1.50	0.09	18.45	101.2	7.6	7.75
396	23-Mar-00	No Test - Stephanie Batch Test Yesterday (3l AN)											
397	24-Mar-00	No Test - New Sewage fed yesterday											
BATCH 28 Averages:		***3187.33***	***2597.56***	***589.78***	***2034.00***	***1677.33***	***356.67***	***1.45***	***0.09***	***17.77***	***94.89***	***7.59***	***7.87***
398	25-Mar-00	No Test - New Sewage											
399	26-Mar-00	3550.0	2872.0	678.0	1890.0	1520.0	370.0	1.59	0.10	17.79	105.8	7.37	7.93
400	27-Mar-00	3464.0	2808.0	656.0	1864.0	1516.0	348.0	1.35	0.10	18.08	96.6	7.68	8.08
401	28-Mar-00	3466.0	2802.0	664.0	1780.0	1434.0	346.0	1.47	0.10	18.19	101.1	7.49	7.94
402	29-Mar-00	3020.0	2454.0	566.0	1844.0	1520.0	324.0	1.37	0.10	17.59	97.6	7.51	7.99
403	30-Mar-00	3472.0	2828.0	644.0	1858.0	1524.0	334.0	1.43	0.10	19.07	91.5	7.5	7.97
404	31-Mar-00	No Test											

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
405	01-Apr-00	No Test											
406	02-Apr-00	3596.0	2920.0	676.0	1796.0	1486.0	310.0	1.53	0.10	17.5	94.7	7.55	8.06
407	03-Apr-00	3648.0	2946.0	702.0	1830.0	1484.0	346.0	1.53	0.11	21.12	92.9	7.54	7.88
BATCH 29 Averages:		***3459.43***	***2804.29***	***655.14***	***1837.43***	***1497.71***	***339.71***	***1.47***	***0.10***	***18.48***	***97.17***	***7.52***	***7.98***
408	04-Apr-00	New Sewage Fed Yesterday, No Test											
409	05-Apr-00	No Test - New Sewage											
410	06-Apr-00	3418.0	2776.0	642.0	1982.0	1626.0	356.0	1.45	0.09	23.74	100.9	7.5	7.76
411	07-Apr-00	No Test											
412	08-Apr-00	No Test											
413	09-Apr-00	3260.0	2606.0	654.0	1886.0	1526.0	360.0	1.45	0.09	21.53	90.1	7.73	8.12
414	10-Apr-00	3602.0	2916.0	686.0	1890.0	1540.0	350.0	1.48	0.09	21.58	95.2	7.69	8.11
415	11-Apr-00	2970.0	2516.0	454.0	1776.0	1534.0	242.0	1.42	0.09	18.29	95.7	7.6	8.03
416	12-Apr-00	3766.0	2980.0	786.0	1902.0	1524.0	378.0	1.48	0.09	17.62	73.6	7.64	8.06
417	13-Apr-00	3290.0	2598.0	692.0	1862.0	1460.0	402.0	1.43	0.10	17.14	91.3	7.63	8.01
418	14-Apr-00	No Test											
419	15-Apr-00	No Test											
420	16-Apr-00	3186.0	2572.0	614.0	1732.0	1402.0	330.0	1.39	0.11	15.86	92.4	7.67	8.09
421	17-Apr-00	New Sewage fed today											
BATCH 30 Averages:		***3356.00***	***2709.14***	***646.86***	***1861.43***	***1516.00***	***345.43***	***1.44***	***0.09***	***19.39***	***91.33***	***7.64***	***8.03***
422	18-Apr-00	Not Test - New Sewage (INCREASED INFLUENT TO 30 l YEST.)											
423	19-Apr-00	No Test - New Sewage											
424	20-Apr-00	Reduced influent to 25 l/d and Sludge Age to 8 days											
425	21-Apr-00	No Test - Adapt to new config.											
426	22-Apr-00	No Test - Adapt to new config.											
427	23-Apr-00	No Test - Adapt to new config.											
428	24-Apr-00	3636.0	3092.0	544.0	1782.0	1580.0	202.0	1.10	0.10	21.05	95.4	7.9	8.38
429	25-Apr-00	3326.0	2790.0	536.0	1876.0	1598.0	278.0	1.49	0.09	19.53	106.6	7.84	8.42
430	26-Apr-00	3974.0	3248.0	726.0	2014.0	1674.0	340.0	1.57	0.09	19.07	94.3	7.42	7.95
431	27-Apr-00	3828.0	3150.0	678.0	2064.0	1762.0	302.0	1.45	0.09	19.28	87.2	7.23	7.54
432	28-Apr-00	4094.0	3308.0	786.0	2108.0	1726.0	382.0	1.59	0.09	21.32	90.1	7.41	7.8
433	29-Apr-00	No Test											
434	30-Apr-00	3954.0	3158.0	796.0	2014.0	1636.0	378.0	1.44	0.10	20.13	89.4	7.47	7.95
435	01-May-00	3834.0	3094.0	740.0	1952.0	1582.0	370.0	1.44	0.10	19.46	82.0	7.39	7.91
436	02-May-00	3498.0	2822.0	676.0	1882.0	1502.0	380.0	1.51	0.10	17.99	101.0	7.29	7.68
437	03-May-00	3804.0	3118.0	686.0	1962.0	1626.0	336.0	1.41	0.09	19.98	91.7	7.55	8.05
438	04-May-00	3876.0	3166.0	710.0	1920.0	1570.0	350.0	1.46	0.09	21.48	88.5	7.51	8
BATCH 31 Averages:		***3782.40***	***3094.60***	***687.80***	***1957.40***	***1625.60***	***331.80***	***1.45***	***0.09***	***19.93***	***92.63***	***7.50***	***7.97***
439	05-May-00	New Sewage Fed Yesterday, No Test											
440	06-May-00	No Test - New Sewage											
441	07-May-00	No Test - New Sewage											
442	08-May-00	3982.0	3238.0	744.0	2020.0	1648.0	372.0	1.45	0.09	26.81	89.1	7.5	8.04
443	09-May-00	3230.0	2624.0	606.0	1890.0	1558.0	332.0	1.50	0.10	25.43	95.2	7.34	7.8
444	10-May-00	4224.0	3438.0	786.0	2112.0	1760.0	352.0	1.35	0.08	26.53	85.2	7.38	7.75
445	11-May-00	3386.0	2742.0	644.0	1994.0	1614.0	380.0	1.46	0.09	27.91	80.2	7.47	7.95
446	12-May-00	3962.0	3264.0	698.0	2362.0	1966.0	396.0	1.46	0.08	27.31	80.4	7.15	7.45
447	13-May-00	No Test											
448	14-May-00	3546.0	2928.0	618.0	2182.0	1822.0	360.0	1.42	0.08	26.73	91.7	7.44	7.98
449	15-May-00	3910.0	3100.0	810.0	2122.0	1716.0	406.0	1.35	0.08	24.53	84.8	7.55	8.07
450	16-May-00	No Test - No Distilled Water											
451	17-May-00	3910.0	3100.0	810.0	2122.0	1716.0	406.0	1.46	0.08	20.29	84.8	7.37	7.79
452	18-May-00	4396.0	3594.0	802.0	1978.0	1696.0	282.0	1.42	0.09	25.37	91.0	7.52	7.79
453	19-May-00	No Test											
454	20-May-00	No Test											
455	21-May-00	5586.0	4610.0	976.0	2312.0	1888.0	424.0	1.63	0.09	24.2	86.5	7.58	7.91
456	22-May-00	Cleaned Unit											
BATCH 32 Averages:		***4013.20***	***3263.80***	***749.40***	***2109.40***	***1738.40***	***371.00***	***1.45***	***0.09***	***25.51***	***86.91***	***7.43***	***7.85***
457	23-May-00	New Sewage Fed Today											
458	24-May-00	WISA											
459	25-May-00	WISA											
460	26-May-00	WISA											
461	27-May-00	WISA											
462	28-May-00	WISA											
463	29-May-00	WISA											
464	30-May-00	WISA											
465	31-May-00	WISA											
466	01-Jun-00	WISA											
467	02-Jun-00	WISA											
468	03-Jun-00	WISA											
469	04-Jun-00	Steering Committee											
470	05-Jun-00	Research Seminar											
BATCH 33 Averages:		-	-	-	-	-	-	-	-	-	-	-	-
471	06-Jun-00	New Sewage Fed											

		mg *ss/l								mgO/l/h			
		TSS	VSS	ISS	TSS	VSS	ISS	COD/VSS Ratio	TKN/VSS Ratio	OUR	DSVI	pH	
Day No.	Date	PreANO	PreANO	PreANO	AE	AE	AE	AE	AE	AE	AE	AN	AE
472	07-Jun-00	No Test - New Sewage											
473	08-Jun-00	Reduce Sludge Age from 8 to 5 Days (install cont. waste)											
474	09-Jun-00	No Test											
475	10-Jun-00	No Test											
476	11-Jun-00	3262.0	2704.0	558.0	1654.0	1388.0	266.0	1.53	0.09	13.34	96.7	7.95	7.87
477	12-Jun-00	3018.0	2446.0	572.0	1634.0	1316.0	318.0	1.48	0.10	19.91	97.9	7.93	7.8
478	13-Jun-00	3064.0	2524.0	540.0	1390.0	1174.0	216.0	1.51	0.13	21.29	107.9	7.77	7.76
479	14-Jun-00	3476.0	2844.0	632.0	1368.0	1190.0	178.0	1.37	0.09	18.95	87.7	7.92	8
480	15-Jun-00	2160.0	1768.0	392.0	1324.0	1080.0	244.0	1.60	0.11	17.83	98.2	7.93	7.95
481	16-Jun-00	2080.0	1722.0	358.0	1204.0	1008.0	196.0	1.54	0.11	15.66	99.7	7.76	7.71
482	17-Jun-00	No Test											
483	18-Jun-00	2258.0	1768.0	490.0	1294.0	1080.0	214.0	1.09	0.10	17.17	61.8	7.94	7.85
BATCH 34 Averages:		*2759.71*	*2253.71*	*506.00*	*1409.71*	*1176.57*	*233.14*	*1.44*	*0.11*	*17.74*	*92.85*	*7.89*	*7.85*

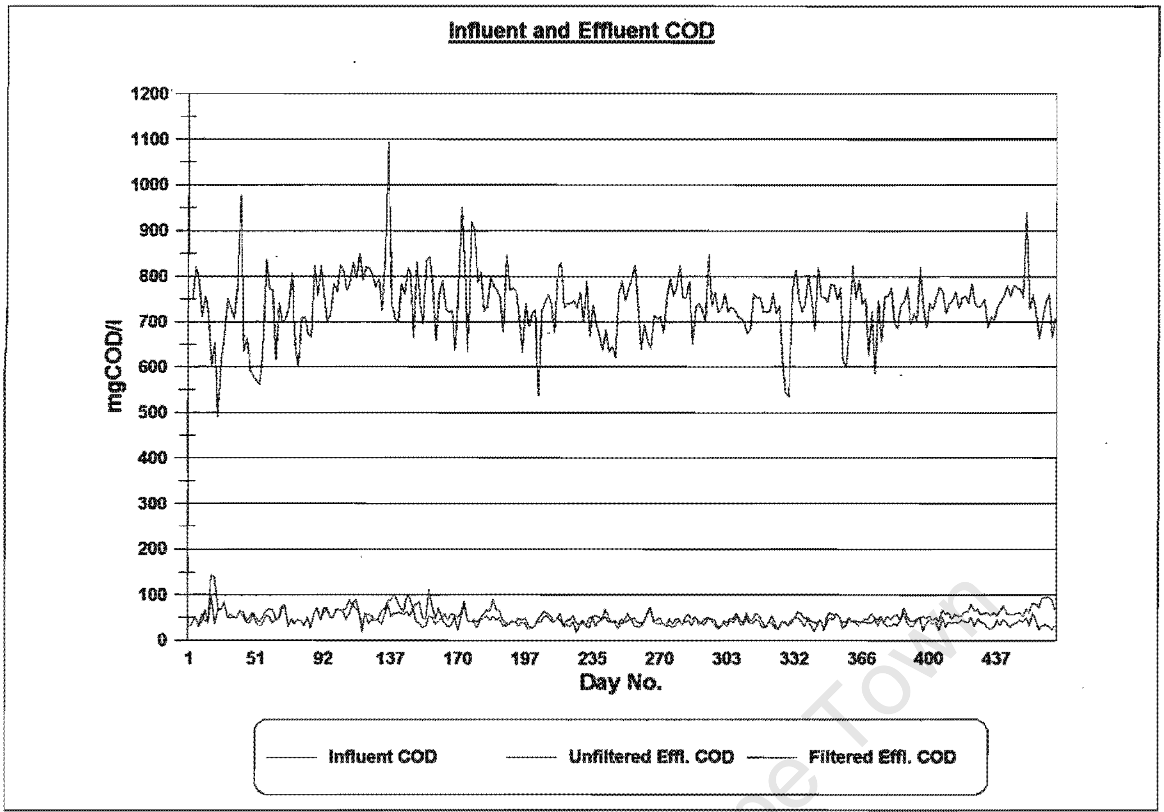

FIGURE A1 - Daily unfiltered influent, unfiltered and filtered effluent COD concentrations for the ENBNRAS system.

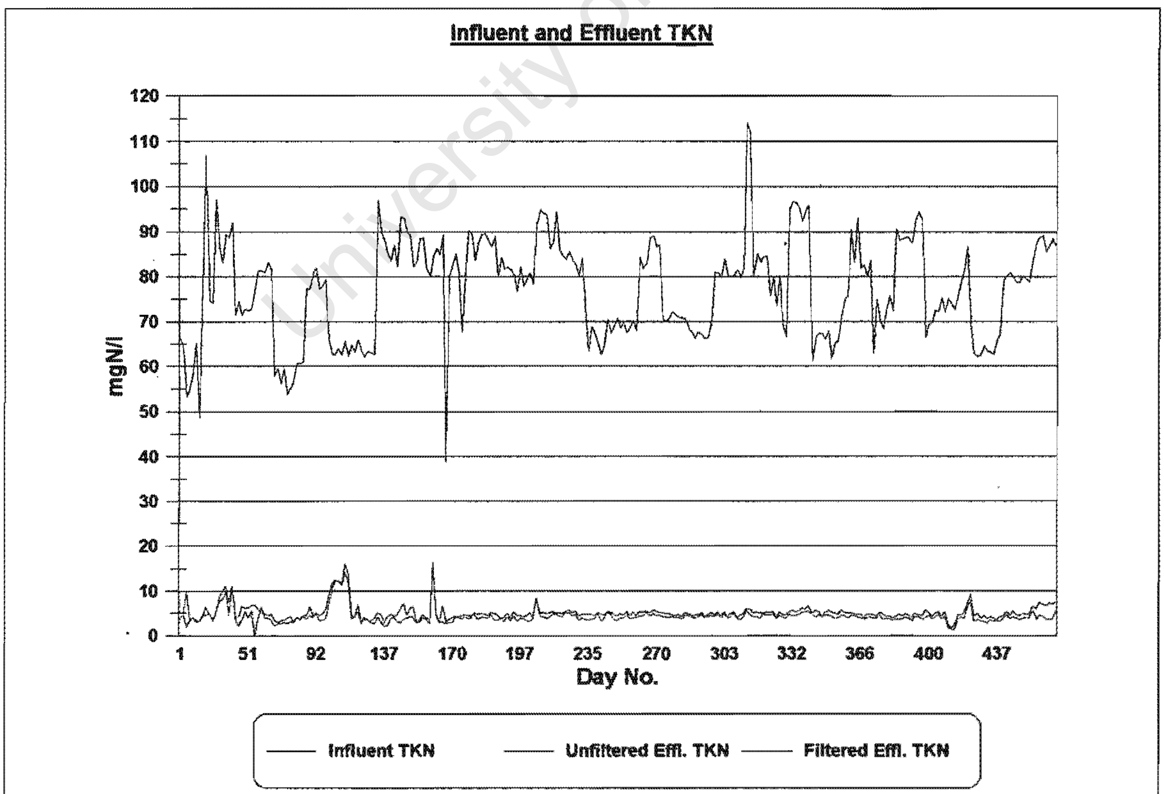

FIGURE A2 - Daily unfiltered influent, unfiltered and filtered effluent TKN concentrations for the ENBNRAS system.

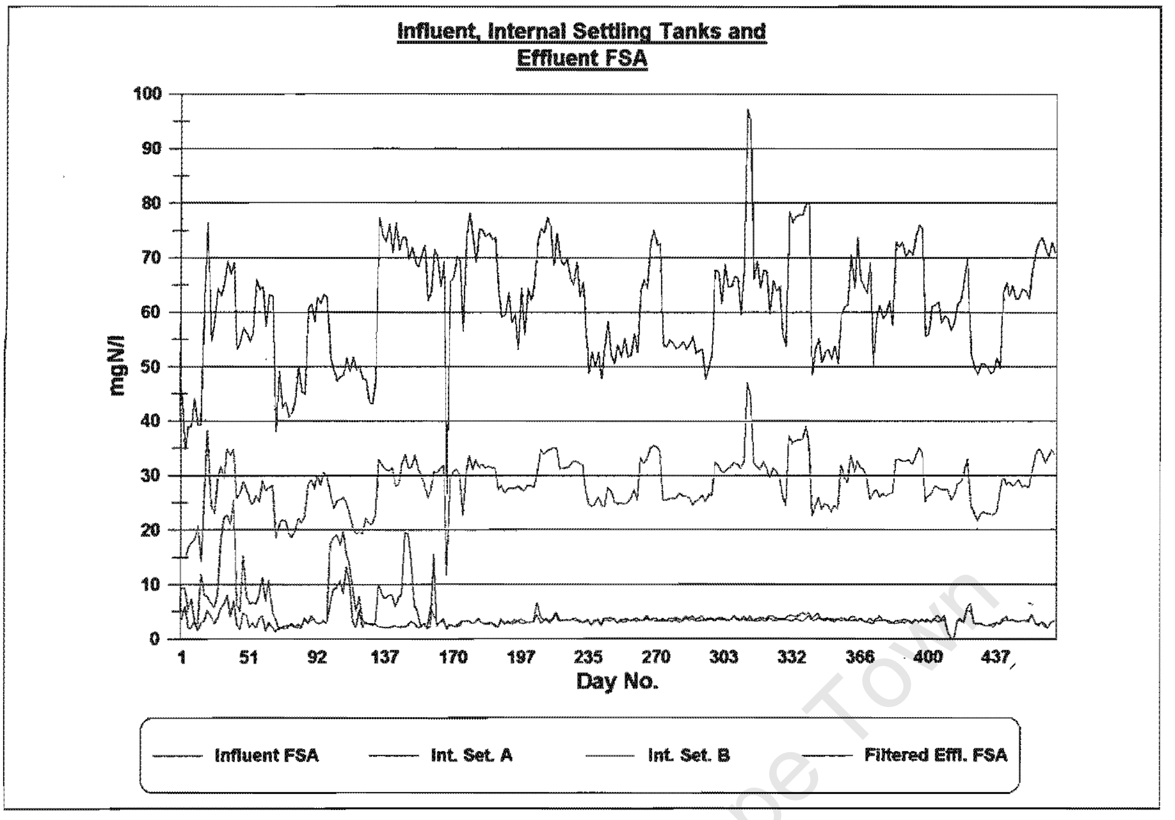

FIGURE A3 - Daily unfiltered influent, internal settler A, internal settler B and filtered effluent FSA concentrations for the ENBNRAS system.

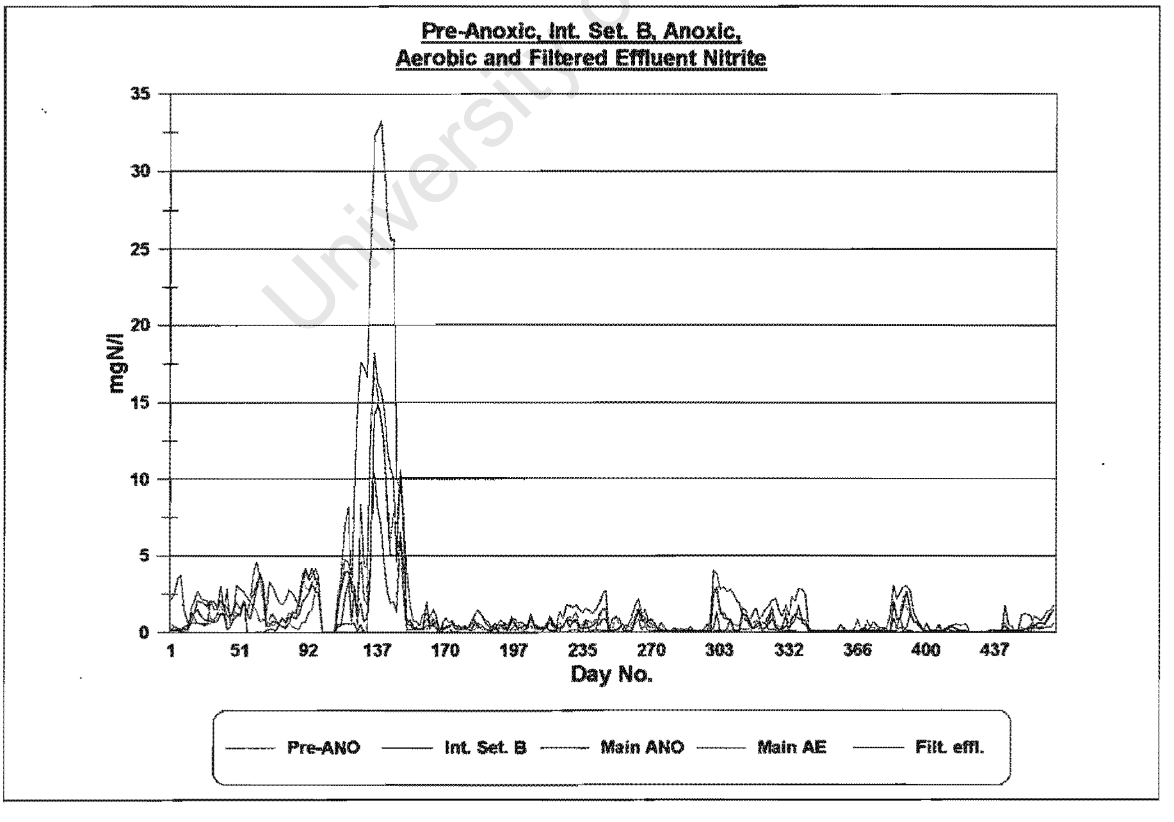

FIGURE A4 - Daily pre-anoxic, internal settler B, main anoxic, main aerobic and filtered effluent nitrite concentrations for the ENBNRAS system.

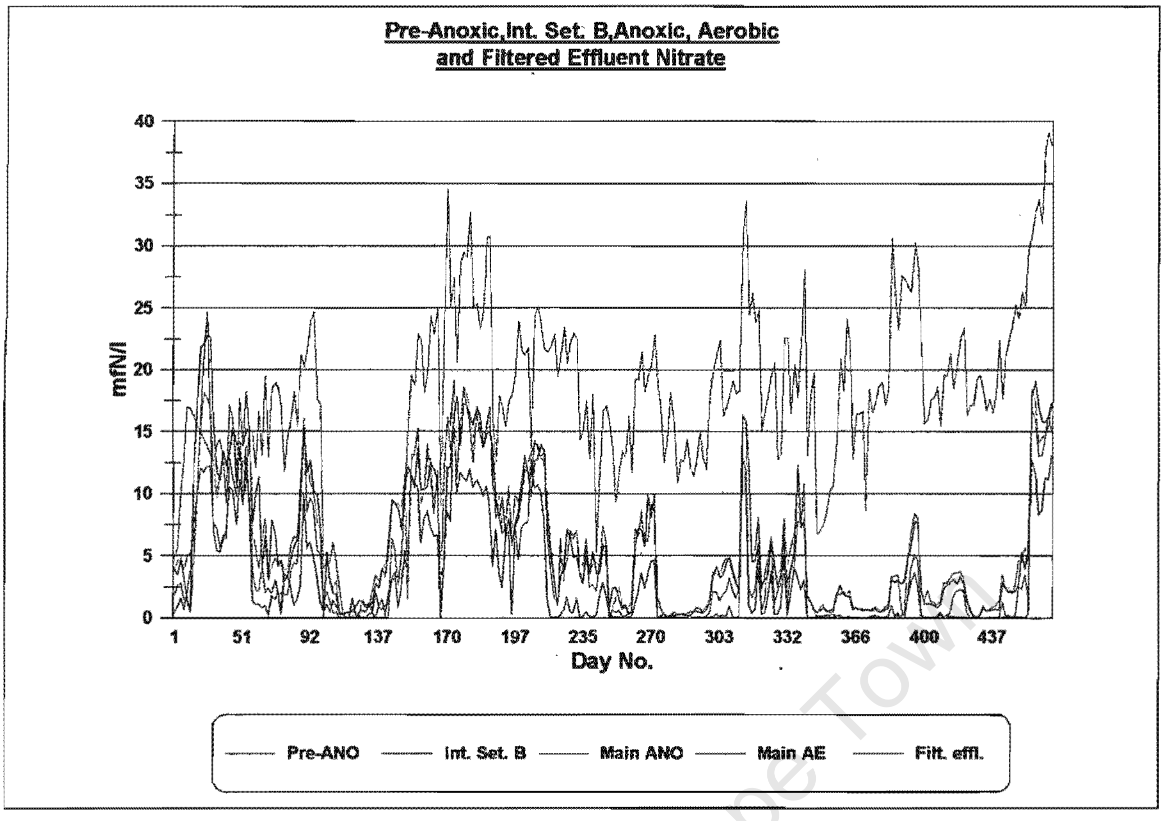

FIGURE A5 - Daily pre-anoxic, internal settler B, main anoxic, main aerobic and filtered effluent nitrate concentrations for the ENBNRAS system.

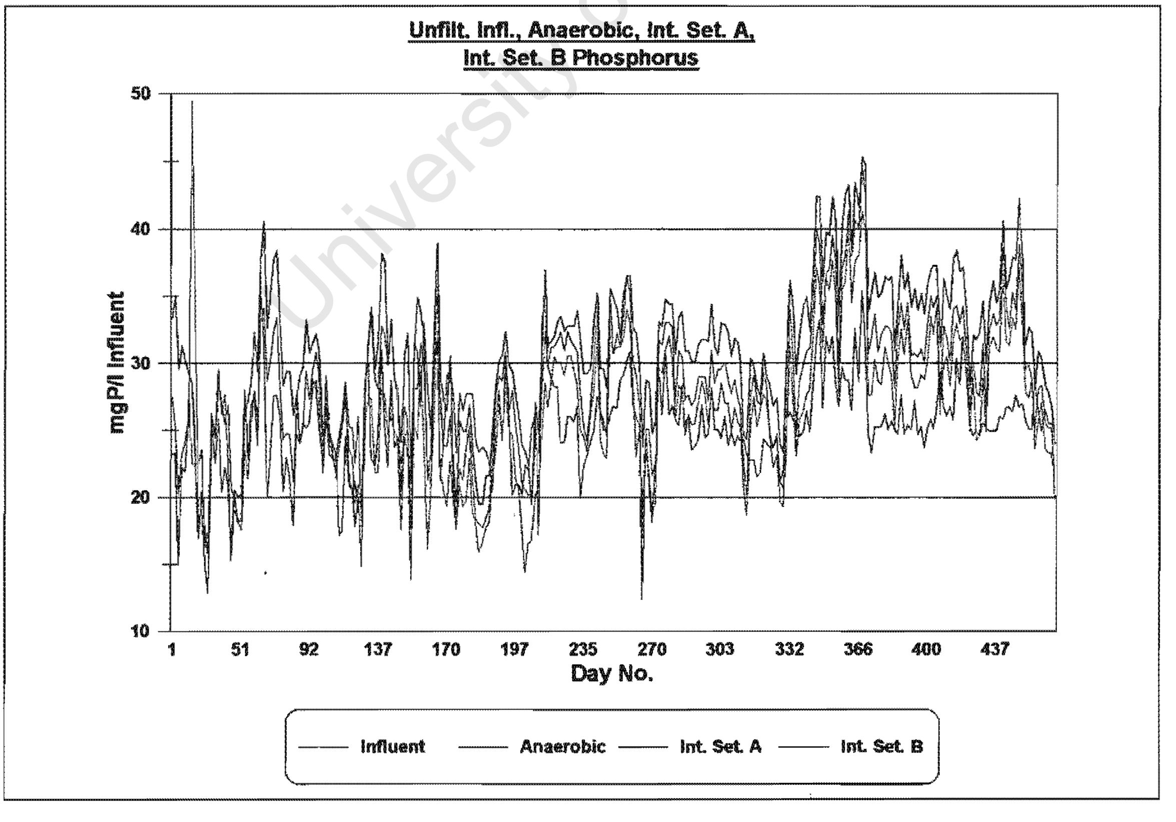

FIGURE A6 - Daily unfiltered influent, anaerobic, internal settler A and internal settler B phosphorus concentrations (viz. P release) for the ENBNRAS system.

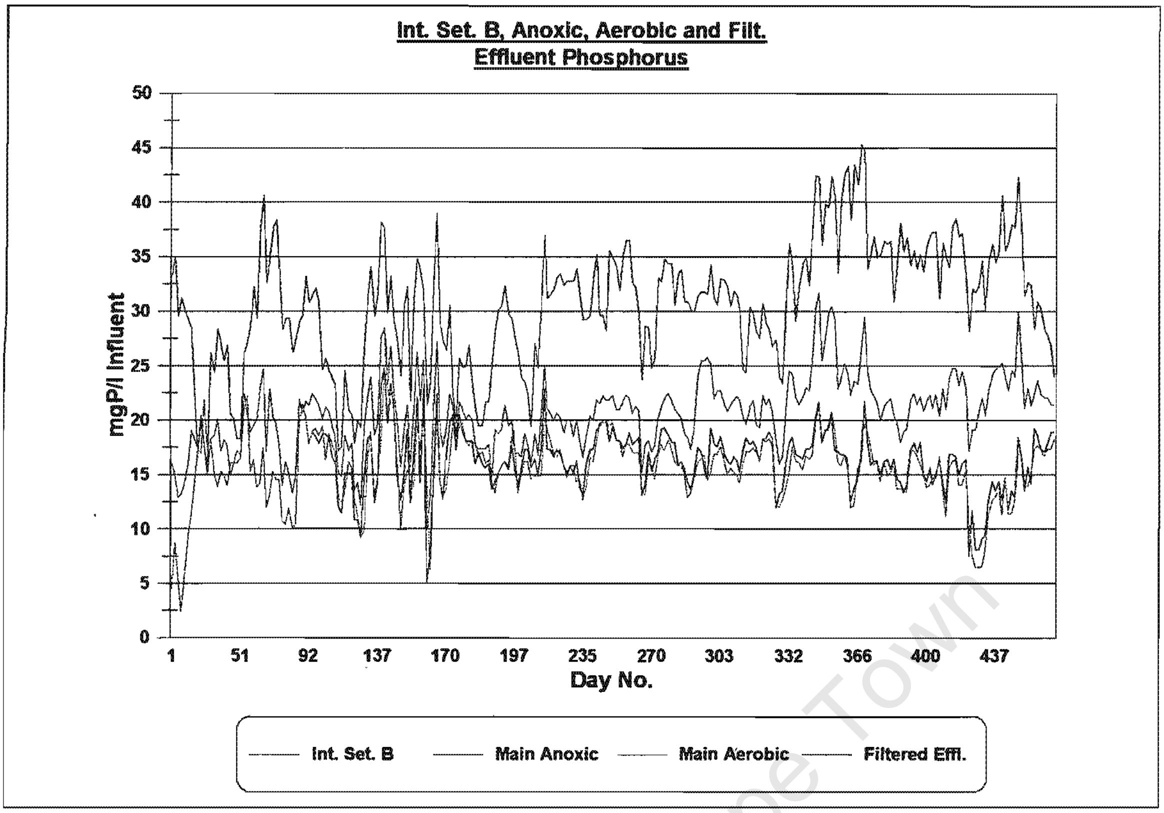

FIGURE A7 - Daily internal settler B, main anoxic, main aerobic and filtered effluent phosphorus concentrations (viz. P uptkake) for the ENBNRAS system.

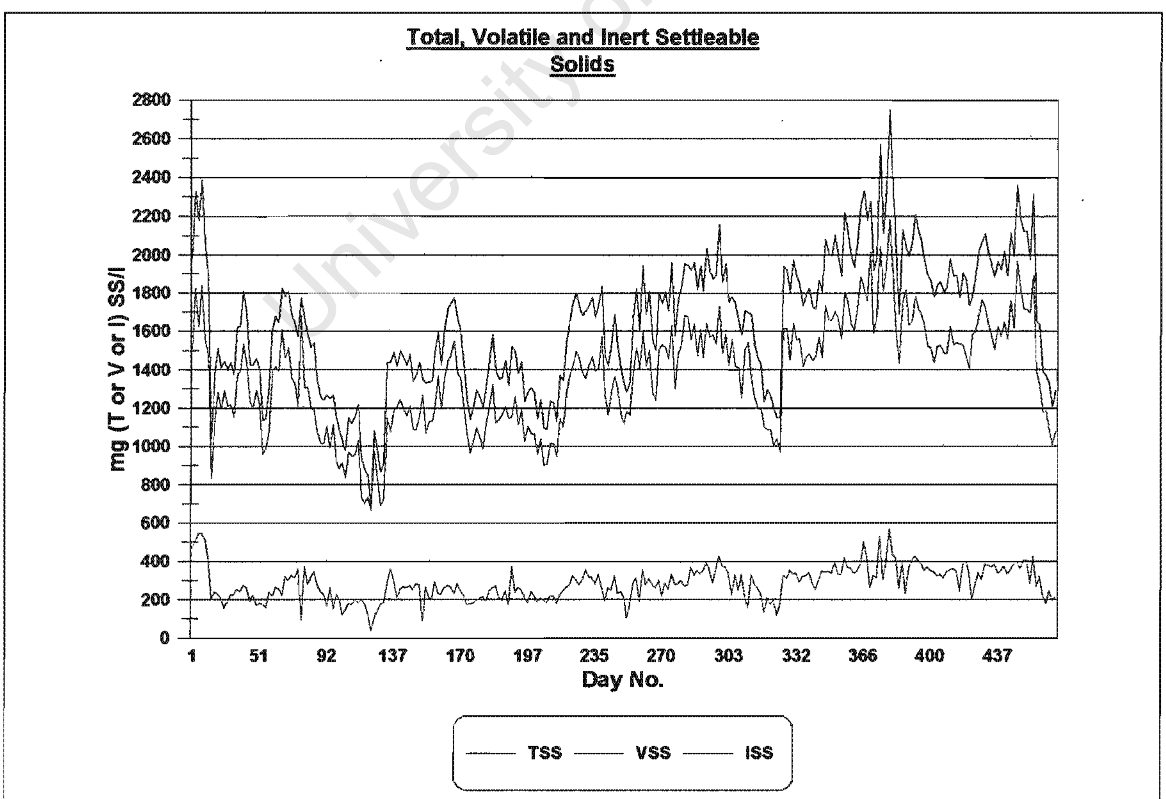

FIGURE A8 - Daily total, volatile and inert suspended solid concentrations for the ENBNRAS system.

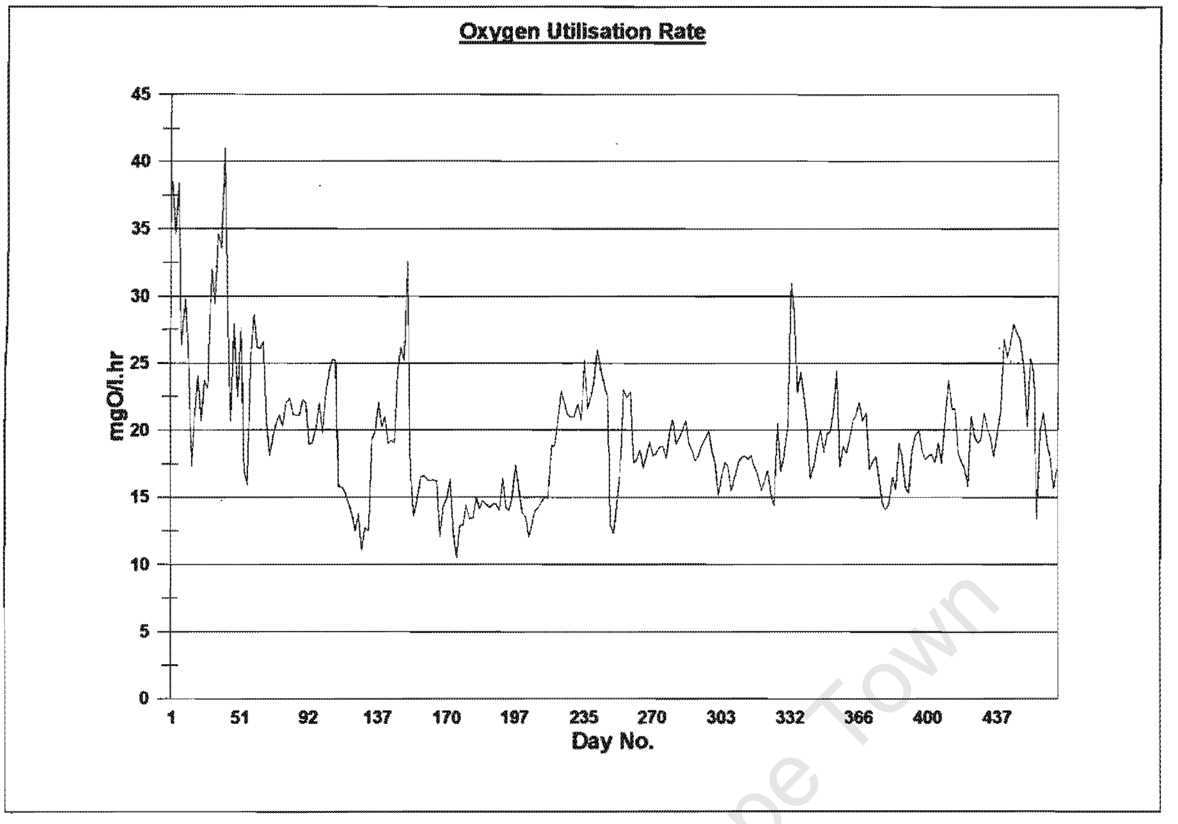

FIGURE A9 - Daily oxygen utilisation rate for the ENBNRAS system.

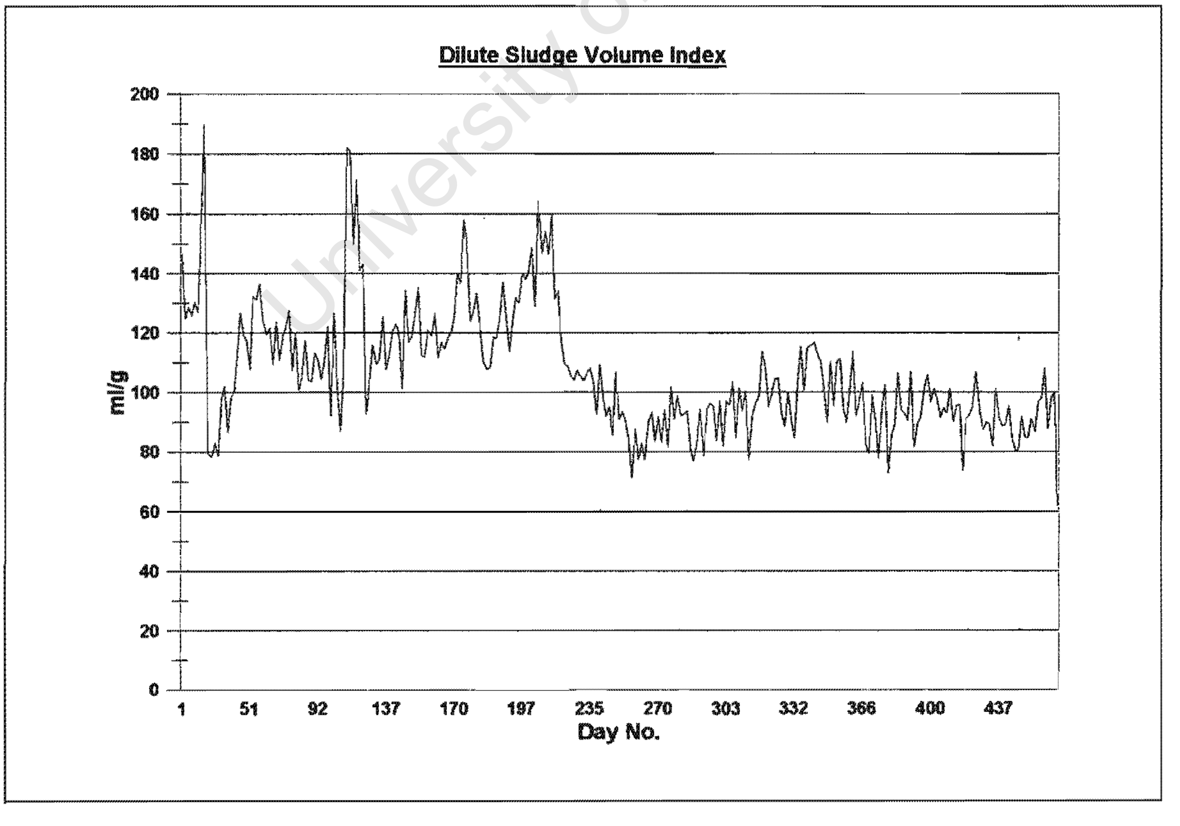

FIGURE A10 - Daily DSVI for the ENBNRAS system.

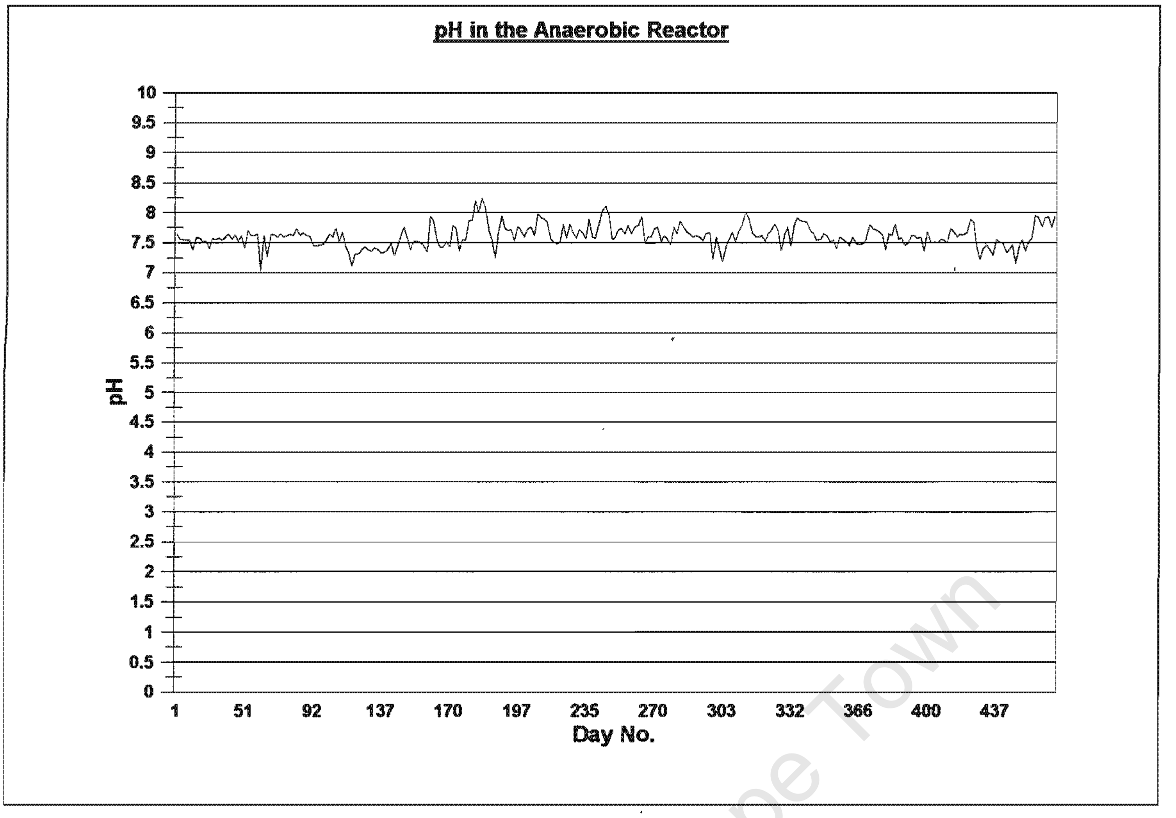

FIGURE A11 - Daily pH values in the anaerobic reactor of the ENBNRAS system.

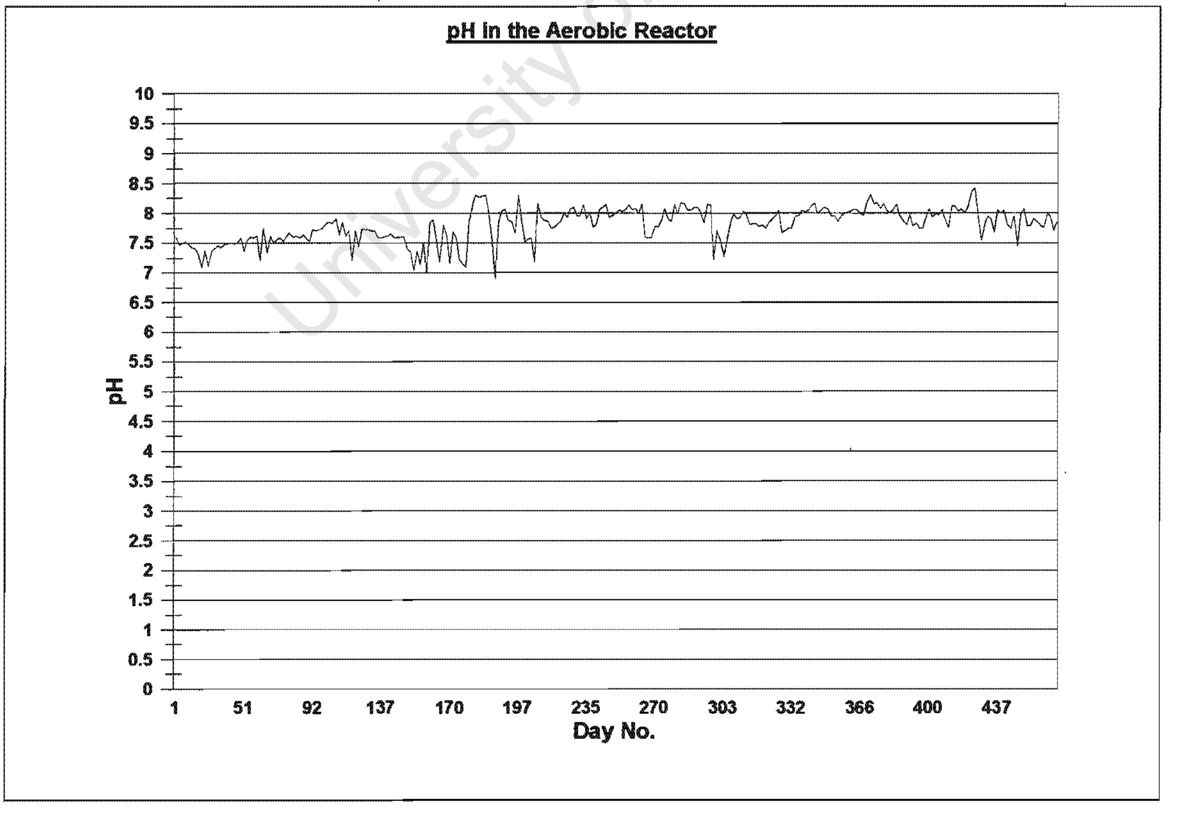

FIGURE A12 - Daily pH values in the main aerobic reactor of the ENBNRAS system.

APPENDIX B

THE METHOD USED FOR CALCULATING THE MASS BALANCES

General mass balances for each reactor and settling tank

The following general principle is used to calculate the change (Δ) for a compound across a reactor or settling tank:

Δ Reactor or Settler = [Mass entering the reactor or settler] - [Mass exiting the reactor or settler]

which is then expressed as:

Δ = [(Flow in) x (Previous reactor concentration)] - [(Flow out) x (Reactor concentration)]

where the flows are expressed with respect to the system influent flow, for example, if the influent flow is 20 l/day and the a-recycle is 40 l/d the a-recycle is expressed as 2.

The Δ for each reactor and settling tank for the ENBNRAS system is shown below, and for purpose of illustration the parameters for Configuration 1 (see Table 3.1) are used:

- Influent flow of 20 l/d
- a-Recycle = 2 (with respect to influent flow, i.e. 40 l/d)
- s-Recycle = 1 (with respect to influent flow, i.e. 20 l/d)
- Sludge bypass = 0.12 (with respect to influent flow, i.e. 2.4 l/d)
- Nitrifier sludge return = 1 (with respect to influent flow, i.e. 20 l/d)

Figure B1 shows the configuration details for Configuration 1 of the ENBNRAS system. The following abbreviations are used:

PreAno	= Pre-Anoxic Reactor
AN	= Anaerobic Reactor
SETA	= Internal Settling Tank A
SETB	= Internal Settling Tank B
ExtNit	= External Nitrification Reactor

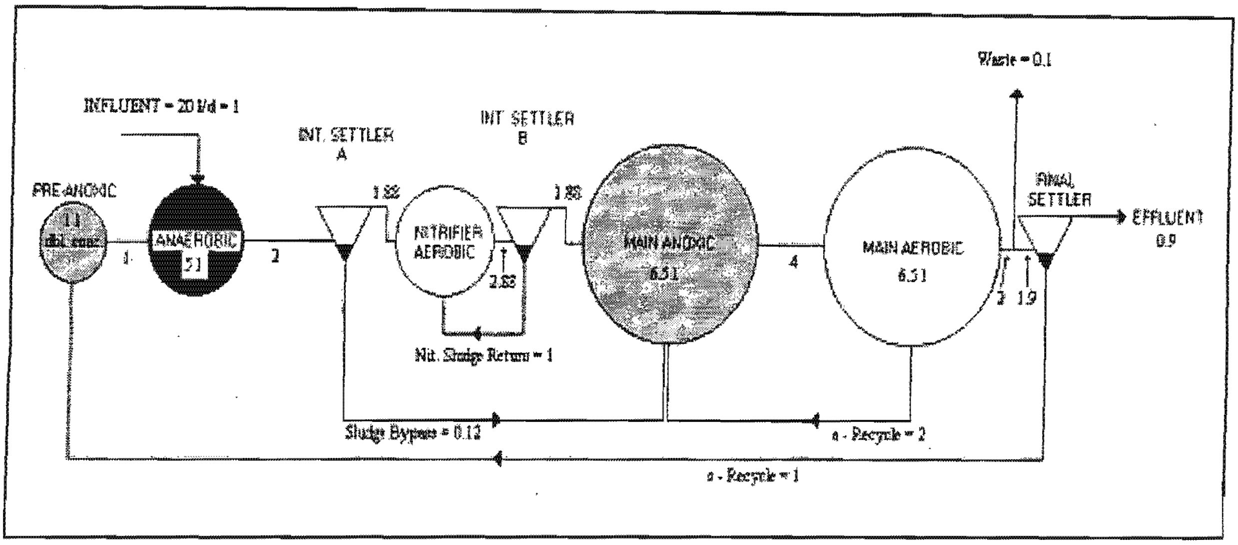

FIGURE B1 - Configuration 1 for the ENBNRAS system showing all flows in terms of the influent flow.

ANO	= Main Anoxic Reactor
AE	= Main Aerobic Reactor
SETF	= Final Settling Tank
Infl.	= Influent
Effl.	= Effluent
[ ]	= Concentration of N / P in Reactor

- ΔPreANO = 1x[Effl.] - 1x[PreAno] **(B.1)**
- ΔAN = { 1x[PreAno] + 1x[Infl.] } - 2x[AN] **(B.2)**
- ΔSETA = 2x[AN] - 2x[SETA] **(B.3)**
- ΔExtNit&SETB = { 1.88x[SETA] + 1x[SETB] } - 2.88x[SETB] **(B.4)**
- ΔANO = { 1.88x[SETB] + 0.12x[SETA] + 2x[AE] } - 4x[ANO] **(B.5)**
- ΔAE = 4x[ANO] - 4x[AE] **(B.6)**
- ΔSETF = 1.9x[AE] - 1.9x[Effl.] **(B.7)**

Phosphorus mass balances for each reactor and settling tank

The method for calculating mass balances across each reactor and settling tank as outlined above (Equations B.1 - B.7) was used to calculate the P mass balances (P release or P uptake) for each reactor and settling tank. As an example, the sewage batch *average* P concentrations for sewage batch 11 (from Table 3.4c) are used to calculate the sewage batch average P release and P uptake for each reactor and settling tank (as listed in Table 3.8):

TABLE B1 - P concentrations for sewage batch 11, as taken from Table 3.4c.

Sewage Batch	Infl. mgP/l	PreAno mgP/l	AN mgP/l	SET A mgP/l	SET B mgP/l	ANO mgP/l	AE mgP/l	UE mgP/l	FE mgP/l
11	23.4	15.3	23.7	28.0	30.7	21.7	17.8	18.4	17.3

- ΔPreANO = 1(17.3) - 1(15.3) = 2 mgP/l influent (P uptake)
- ΔAN = {1(15.3) + 1(23.4) } - 2(23.7) = -8.7 mgP/l infl. (P release)
- ΔSETA = 2(23.7) - 2(28.0) = -8.6 mgP/l influent
- ΔExtNit&SETB = { 1.88(28.0) + 1(30.7) } - 2.88(30.7) = -5.0 mgP/l influent
- ΔANO = { 1.88(30.7) + 0.12(28.0) + 2(17.8) } - 4(21.7) = 9.8 mgP/l infl.
- ΔAE = 4(21.7) - 4(17.8) = 15.6 mgP/l influent
- ΔSETF = 1.9(17.8) - 1.9(17.3) = 0.9 mgP/l influent

Nitrite and nitrate mass balances for each reactor and settler and total N mass balance

The nitrite and nitrate mass balances for each reactor and settler are calculated by the same method as for the phosphorus mass balances for each reactor and settler above (Equations B.1 - B.7). Continuing with sewage batch 11 as an example, Table B2 shows the sewage batch average values obtained for the nitrite mass balance across each reactor and settler, and Table B3 shows the sewage batch average values obtained for the nitrate mass balance across each reactor and settler.

TABLE B2 - Nitrite mass balances across each reactor and settler for sewage batch 11 with a positive value indicating denitrification and a negative value indicating nitrification.

Sewage Batch	Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ ExtNit&SETB mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ SETF mgN/d
11	78.2	72.4	-6.0	-725.5	321.0	53.1	47.0

TABLE B3 - Nitrate mass balances across each reactor and settler for sewage batch 11 with a positive value indicating denitrification and a negative value indicating nitrification.

Sewage Batch	Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ ExtNit&SETB mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ SETF mgN/d
11	74.5	55.0	-3.8	-165.4	207.2	-289.5	-13.0

The total N mass balance is then calculated by reconciling the influent N with the N exiting the system as nitrogen gas (denitrification), N in the waste sludge, N in the effluent and N taken up in the EN system.

Influent N = [TKN in the influent] x Q_i **B.8**

i.e. IN is ≥ OUT, ⇒ mass is "lost"/consumed.

N exiting the system:

NO_2 denitrified =Σ positive values from Table B2 **B.9**

NO_3 denitrified = Σ positive values from Table B3 **B.10**

N wasted = ([TKN in AE] x Q_w) + ([NO_2 in AE] x Q_w) + ([NO_3 in AE] x Q_w) **B.11**

N in the effluent = ([TKN in effluent] x Q_e) + ([NO_2 in effluent] x Q_e) + ([NO_3 in effluent] x Q_e) **B.12**

N 'loss' EN system = {([FSA in SETA] x1.88Q_i) + ([NO_2 in SETA] x1.88Q_i) + ([NO_3 in SETA] x1.88Q_i)} - {([FSA in SETB] x1.88Q_i) + ([NO_2 in SETB] x1.88Q_i) + ([NO_3 in SETB] x1.88Q_i)} **B.13**

Where Q_i = Influent flow, Q_w = Waste flow and $Q_e = Q_i - Q_w$.

By substituting the corresponding values into equation B.8 (for the influent N) and equations B.9 to B.13 (for the N exiting the system) a value for the N entering the system (in mgN/d) and a value for the N exiting the system (the sum of the results of equations B.9 to B.13, in mgN/d) is calculated. The total N mass balance is then expressed as:

%N recovery = {(N exiting the system) / (N entering the system)} x 100

COD mass balance

The COD mass balance is calculated using the same principle as for the total N mass balance. The COD entering the system is reconciled with the COD leaving the system via the system effluent and the waste sludge, e^- passed to oxygen, COD utilised in denitrification of NO_3 and NO_2 and COD consumed in the EN system.

Influent COD = [COD of unfiltered influent] x Q_i **B.14**

COD exiting the system:

COD in effluent = [COD of unfiltered effluent] x Q_e **B.15**

COD wasted = [COD of AE mixed liquor] x Q_w **B.16**

Carbonaceous O_2 = (OUR x volume of AE x 24) - (O_2 utilised for nitrification in AE)
= OUR (in mgO/d) - (3.43 x [NO_2 nitrified in AE] x Q_i) - (4.57 x [NO_3 nitrified in AE] x Q_i) ie. $MNO_{2,d}$ $MNO_{3,d}$ **B.17**

COD util. for denit. = (1.71 x Σ positive values from Table B2) + (2.86 x Σ positive values from Table B3) **B.18**

COD 'loss' EN sys. = ([COD of SETA supernatant] x 1.88Q_i) - ([COD of SETB supernatant] x 1.88Q_i) **B.19**

where Q_i = Influent flow, Q_w = Waste flow and Q_e = Q_i - Q_w, and
3.43 = mass of oxygen utilised per mg NO_2 nitrified.
4.57 = mass of oxygen utilised per mg NO_3 nitrified.
1.71 = equivalent oxygen demand for NO_2 denitrification.
2.86 = equivalent oxygen demand for NO_3 denitrification.

Equation B.14 gives the influent COD (in mgCOD/d) and the sum of the results of Equations B.15 to B.19 gives the total COD exiting the system (in mgCOD/d). The COD mass balance is then expressed as:

%COD recovery = {(COD exiting the system) / (COD entering the system)} x 100

Day No.	Date	EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
1	22-Feb-99	0.083	-1.0	-52.4	26.4	-11.3	21.7	25.0	10.4	18.7	18.7	100
2	23-Feb-99	0.083	2.4	-39.9	19.4	-19.3	49.1	-19.4	22.2	14.6	14.6	100
3	24-Feb-99	0.083	1.0	9.0	-29.8	-18.0	17.3	30.5	-0.7	9.4	9.4	100
4	25-Feb-99	0.083	-1.7	18.0	-38.2	-15.3	44.5	-18.0	30.5	19.8	19.8	100
5	26-Feb-99											
6	27-Feb-99											
7	28-Feb-99											
8	01-Mar-99	0.083	-4.2	-42.7	26.4	-12.0	50.8	-38.9	36.8	16.3	16.3	100
9	02-Mar-99	0.083	-1.0	-41.6	25.7	-5.3	44.9	-37.5	31.9	17.0	17.0	100
10	03-Mar-99	0.083	-12.4	-60.9	8.3	40.4	49.5	-58.1	44.3	11.1	11.1	100
11	04-Mar-99											
BATCH 1 Averages:		***0.083***	***-2.4***	***-30.1***	***5.4***	***-5.8***	***39.7***	***-16.6***	***25.1***	***15.3***	***15.3***	***100***
12	05-Mar-99											
13	06-Mar-99											
14	07-Mar-99											
15	08-Mar-99											
BATCH 2 Averages:		***Bad Batch***										
16	09-Mar-99											
17	10-Mar-99											
18	11-Mar-99											
19	12-Mar-99											
20	13-Mar-99											
21	14-Mar-99	0.083	0.3	-15.9	18.7	2.7	25.7	-52.6	26.3	5.2	5.2	100
22	15-Mar-99	0.083	-2.4	-13.1	18.0	-2.7	31.0	-59.5	35.3	6.6	6.6	100
23	16-Mar-99											
24	17-Mar-99	0.083	4.1	-9.7	13.1	-4.6	23.3	-47.0	15.2	-5.5	-5.5	100
25	18-Mar-99	0.083	2.1	-57.4	63.6	-5.3	42.6	-83.0	36.7	-0.7	-0.7	100
BATCH 3 Averages:		***0.083***	***1.0***	***-24.0***	***28.4***	***-2.5***	***30.7***	***-60.5***	***28.4***	***1.4***	***1.4***	***100***
26	19-Mar-99											
27	20-Mar-99											
28	21-Mar-99											
29	22-Mar-99	0.083	3.3	-39.7	30.6	-2.8	46.4	-61.1	30.6	7.3	7.3	100
30	23-Mar-99	0.083	0.4	-40.7	28.4	0.7	32.8	-42.2	28.4	7.6	7.6	100
31	24-Mar-99											
32	25-Mar-99	0.083	-1.8	-32.7	15.3	2.1	27.0	-20.4	22.6	12.0	12.0	100
33	26-Mar-99											
34	27-Mar-99											
35	28-Mar-99	0.083	2.9	-40.7	21.1	-1.4	34.1	-29.1	18.2	5.1	5.1	100
36	29-Mar-99	0.083	2.5	-44.7	24.0	4.2	22.7	-16.0	14.6	7.3	7.3	100
37	30-Mar-99											
38	31-Mar-99											
BATCH 4 Averages:		***0.083***	***1.5***	***-39.7***	***23.9***	***0.6***	***32.6***	***-33.8***	***22.8***	***7.9***	***7.9***	***100***
39	01-Apr-99											
40	02-Apr-99											
41	03-Apr-99											
42	04-Apr-99											
43	05-Apr-99	0.083	0.4	-22.4	11.9	-8.6	47.4	-58.2	36.5	7.1	7.1	100
44	06-Apr-99											
45	07-Apr-99											
46	08-Apr-99											
47	09-Apr-99	0.083	1.1	-6.7	7.5	-10.0	36.9	-52.2	23.9	0.4	0.4	100
48	10-Apr-99											
49	11-Apr-99	0.083	0.4	-32.4	30.6	-2.1	38.7	-61.1	30.6	4.5	4.5	100
50	12-Apr-99	0.083	1.1	-17.5	17.2	0.0	37.3	-65.6	30.6	3.0	3.0	100
51	13-Apr-99	0.083	0.7	-63.0	64.1	-1.4	34.2	-61.1	29.8	3.4	3.4	100
52	14-Apr-99											
53	15-Apr-99	0.083	-0.7	-20.5	23.1	-5.0	27.4	-40.3	23.1	7.1	7.1	100
54	16-Apr-99	0.083	5.8	-29.7	26.1	-11.1	35.0	-44.9	19.6	0.7	0.7	100
BATCH 5 Averages:		***0.083***	***1.3***	***-27.5***	***25.8***	***-5.5***	***36.7***	***-54.8***	***27.7***	***3.7***	***3.7***	***100***
55	17-Apr-99											
56	18-Apr-99											
57	19-Apr-99	0.083	1.8	-14.9	4.3	-6.3	41.8	-44.9	29.7	11.6	11.6	100
58	20-Apr-99											
59	21-Apr-99											
60	22-Apr-99	0.083	2.9	-12.7	-2.2	-8.3	18.5	13.0	0.0	11.2	11.2	100
61	23-Apr-99											
62	24-Apr-99											
63	25-Apr-99											
64	26-Apr-99											
65	27-Apr-99	0.083	-2.9	-8.0	-2.9	-6.9	8.4	20.3	2.2	10.1	10.1	100

Day No.	Date	EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
66	28-Apr-99	0.083	-1.4	-14.5	-0.7	-9.0	27.9	2.9	15.9	21.0	21.0	100
67	29-Apr-99	0.083	0.0	-19.9	0.7	-12.5	24.1	14.5	7.2	14.1	14.1	100
BATCH 6 Averages:		*0.083*	*0.1*	*-14.0*	*-0.1*	*-8.6*	*24.1*	*1.2*	*11.0*	*13.6*	*13.6*	*100*
68	30-Apr-99											
69	01-May-99											
70	02-May-99											
71	03-May-99	0.083	0.7	-41.3	15.2	-7.6	43.1	-24.6	22.5	8.0	8.0	100
72	04-May-99	0.083	0.0	-47.8	23.9	-9.7	27.1	-5.8	22.5	10.1	10.1	100
73	05-May-99	0.083	2.2	-48.5	24.6	-10.4	62.6	-56.5	38.4	12.3	12.3	100
74	06-May-99	0.083	1.1	-36.6	10.9	-9.7	51.0	-27.5	23.9	13.0	13.0	100
75	07-May-99	0.083	1.4	-34.8	17.4	-9.7	44.5	-27.5	20.3	11.6	11.6	100
76	08-May-99											
77	09-May-99	0.083	0.7	-24.7	6.4	-7.6	49.1	-41.5	27.2	9.7	9.7	100
78	10-May-99	0.083	-0.7	-26.9	11.5	-8.9	37.6	-22.9	22.9	12.5	12.5	100
79	11-May-99	0.083	2.9	-20.4	1.4	-8.9	33.3	-10.0	11.5	9.7	9.7	100
80	12-May-99	0.083	2.1	-15.0	-1.4	-9.6	42.6	-34.4	23.6	7.9	7.9	100
81	13-May-99	0.083	0.0	-17.2	5.7	-5.5	31.3	-12.9	15.8	17.2	17.2	100
82	14-May-99											
BATCH 7 Averages:		*0.083*	*1.0*	*-31.3*	*11.6*	*-8.8*	*42.2*	*-26.4*	*22.9*	*11.2*	*11.2*	*100*
83	15-May-99											
84	16-May-99	0.083	1.8	-21.1	15.0	-9.6	33.3	-38.7	23.6	4.3	4.3	100
85	17-May-99	0.083	2.1	-10.5	4.9	-8.7	31.8	-28.0	12.6	4.2	4.2	100
86	18-May-99	0.083	3.1	-26.2	9.8	-7.4	34.6	-23.8	14.7	4.9	4.9	100
87	19-May-99											
88	20-May-99											
89	21-May-99											
90	22-May-99											
91	23-May-99											
92	24-May-99	0.083	1.4	-9.8	-2.8	-6.7	11.6	14.0	0.0	7.7	7.7	100
93	25-May-99	0.083	1.7	-10.1	-2.8	-4.0	11.0	14.0	0.0	9.8	9.8	100
94	26-May-99	0.083	2.4	-12.2	-4.2	-2.7	13.2	14.0	-1.4	9.1	9.1	100
95	27-May-99	0.083	1.7	-12.6	-3.5	-3.4	11.7	14.0	-1.4	6.6	6.6	100
96	28-May-99											
97	29-May-99											
98	30-May-99											
BATCH 8 Averages:		*0.083*	*2.1*	*-14.7*	*2.3*	*-6.1*	*21.0*	*-4.9*	*6.9*	*6.7*	*6.7*	*100*
99	31-May-99											
100	01-Jun-99											
101	02-Jun-99	0.100	1.7	-3.5	-4.2	-1.3	6.2	5.5	-1.4	3.1	3.1	100
102	03-Jun-99											
BATCH 9 Averages:		*Bad Batch*										
103	04-Jun-99											
104	05-Jun-99											
105	06-Jun-99	0.100	-2.4	-4.2	-2.1	2.6	4.3	9.7	4.8	12.8	12.8	100
106	07-Jun-99	0.100	0.7	-3.5	-1.4	-1.3	2.7	9.7	-0.7	6.2	6.2	100
107	08-Jun-99	0.100	-0.7	-4.2	-1.4	-0.7	3.4	11.1	-2.1	5.5	5.5	100
108	09-Jun-99	0.100	0.7	-7.6	0.0	-0.7	4.8	9.7	-2.1	4.8	4.8	100
109	10-Jun-99											
110	11-Jun-99											
111	12-Jun-99											
112	13-Jun-99											
113	14-Jun-99											
114	15-Jun-99											
115	16-Jun-99	0.150	0.3	-11.1	-2.0	13.7	-0.9	12.1	-1.3	10.8	10.8	100
116	17-Jun-99	0.150	0.7	-13.1	-1.3	15.5	-0.1	13.4	-2.0	13.1	13.1	100
117	18-Jun-99											
118	19-Jun-99											
119	20-Jun-99	0.150	-0.7	-11.8	-2.7	7.5	6.0	13.4	3.4	15.1	15.1	100
120	21-Jun-99	0.150	2.0	-11.8	-3.4	8.1	4.0	8.1	-2.0	5.0	5.0	100
121	22-Jun-99	0.150	1.0	-10.8	-4.7	8.7	0.7	10.8	-0.7	5.0	5.0	100
122	23-Jun-99	0.150	3.0	-8.1	-6.0	8.7	4.1	10.8	-4.0	8.4	8.4	100
123	24-Jun-99											
124	25-Jun-99											
125	26-Jun-99											
126	27-Jun-99											
127	28-Jun-99	0.150	-1.0	-10.5	-10.1	11.2	5.6	13.5	-0.7	8.1	8.1	100
128	29-Jun-99											
129	30-Jun-99	0.150	2.4	-7.8	-6.7	-1.9	7.9	12.1	0.0	6.1	6.1	100
130	01-Jul-99	0.150	-3.7	-8.4	-4.0	0.6	5.4	18.9	9.4	18.2	18.2	100
131	02-Jul-99	0.150	-0.7	-7.8	-7.4	0.6	10.8	14.8	4.0	14.5	14.5	100

Day No.	Date	EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
132	03-Jul-99											
133	04-Jul-99											
134	05-Jul-99											
BATCH 10 Averages:		***0.136***	***0.1***	***-8.6***	***-3.8***	***5.2***	***4.2***	***12.0***	***0.4***	***9.6***	***9.6***	***100***
135	06-Jul-99	0.185	3.0	-15.9	-12.1	-1.2	9.3	21.6	-0.7	4.0	4.0	100
136	07-Jul-99	0.185	2.5	-10.9	-13.8	-1.3	9.3	24.8	-1.5	9.1	9.1	100
137	08-Jul-99	0.185	2.2	-6.6	-12.4	-6.6	12.4	21.8	-0.7	10.2	10.2	100
138	09-Jul-99	0.185	-2.2	-5.1	-9.5	-9.9	11.4	17.5	10.9	13.1	13.1	100
139	10-Jul-99	0.185	1.8	-6.9	-8.7	-9.9	9.9	14.6	0.0	0.7	0.7	100
140	11-Jul-99	0.185	5.5	-9.8	-10.2	0.0	5.8	14.6	-6.6	-0.7	-0.7	100
141	12-Jul-99											
142	13-Jul-99	0.185	0.4	-2.3	-13.8	-0.7	6.0	13.8	3.8	7.3	7.3	100
143	14-Jul-99	0.185	4.6	-9.6	-7.6	-0.7	9.9	6.1	0.0	2.7	2.7	100
144	15-Jul-99	0.185	3.1	-11.5	-7.6	1.4	5.5	19.9	-3.1	7.6	7.6	100
145	16-Jul-99											
146	17-Jul-99											
147	18-Jul-99	0.185	0.8	-3.4	-4.6	-7.6	9.9	12.2	5.4	12.6	12.6	100
148	19-Jul-99	0.185	2.3	-13.0	-4.6	-6.9	13.8	16.8	2.3	10.7	10.7	100
149	20-Jul-99											
150	21-Jul-99	0.185	-2.2	-9.4	-0.7	-12.2	16.0	9.0	7.5	7.9	7.9	100
151	22-Jul-99	0.185	4.9	3.4	-7.5	-7.5	4.5	13.5	-5.2	6.0	6.0	100
152	23-Jul-99											
BATCH 11 Averages:		***0.185***	***2.0***	***-7.8***	***-8.7***	***-4.9***	***9.5***	***15.8***	***0.9***	***7.0***	***7.0***	***100***
153	24-Jul-99											
154	25-Jul-99											
155	26-Jul-99	0.185	0.0	-5.6	-5.2	-5.4	10.7	18.0	5.2	17.6	17.6	100
156	27-Jul-99	0.185	-0.4	1.9	-7.5	-12.2	7.7	16.5	5.2	11.2	11.2	100
157	28-Jul-99	0.220	5.2	-21.3	-3.0	-4.0	8.5	30.0	-6.0	9.4	9.4	100
158	29-Jul-99											
159	30-Jul-99	0.220	-0.7	5.2	-11.2	-3.3	7.1	10.5	5.2	12.7	12.7	100
160	31-Jul-99											
161	01-Aug-99											
162	02-Aug-99	0.220	10.7	-1.1	-11.8	1.3	13.4	19.1	-17.6	14.0	14.0	100
163	03-Aug-99	0.220	1.1	-10.3	-1.5	-4.6	10.5	20.6	2.9	18.7	18.7	100
164	04-Aug-99											
165	05-Aug-99	0.220	0.0	-8.5	-5.9	-5.9	11.0	22.1	3.7	16.5	16.5	100
166	06-Aug-99	0.220	0.4	-13.2	-6.6	-5.9	13.2	19.1	4.4	11.4	11.4	100
BATCH 12 Averages:		***0.211***	***2.0***	***-6.6***	***-6.6***	***-5.0***	***10.2***	***19.5***	***0.4***	***13.9***	***13.9***	***100***
167	07-Aug-99											
168	08-Aug-99	0.220	-3.3	-4.8	-8.9	-4.6	10.6	17.9	0.0	6.7	6.7	100
169	09-Aug-99	0.220	1.9	-5.2	-6.7	-6.0	8.9	19.3	-0.7	11.5	11.5	100
170	10-Aug-99	0.220	-0.7	4.8	-8.9	-4.6	8.4	10.4	6.0	15.3	15.3	100
171	11-Aug-99	0.220	-1.5	1.9	-6.7	-7.9	10.2	10.4	6.7	13.0	13.0	100
172	12-Aug-99											
173	13-Aug-99	0.220	0.4	7.1	-2.2	-2.0	0.5	3.0	0.7	7.4	7.4	100
174	14-Aug-99											
175	15-Aug-99	0.220	1.2	5.6	-1.6	-2.1	-0.3	4.8	-3.2	4.4	4.4	100
176	16-Aug-99	0.220	-1.2	6.4	-2.4	-6.4	4.6	4.8	2.4	8.4	8.4	100
177	17-Aug-99	0.220	2.0	5.6	-4.0	-6.4	3.2	8.0	-1.6	6.8	6.8	100
178	18-Aug-99	0.220	1.6	4.8	-8.0	-2.1	5.3	8.0	0.0	9.6	9.6	100
179	19-Aug-99	0.220	0.8	-1.2	-4.8	-2.9	7.7	9.6	0.8	10.0	10.0	100
180	20-Aug-99	0.220	0.8	7.2	-4.8	-4.3	2.7	8.0	0.0	9.6	9.6	100
181	21-Aug-99											
182	22-Aug-99	0.220	3.2	2.5	-0.7	-5.0	2.9	7.1	-3.5	8.4	8.4	100
183	23-Aug-99	0.220	0.7	7.4	-4.2	-2.5	3.2	1.4	0.7	6.7	6.7	100
184	24-Aug-99	0.220	1.8	5.7	-2.1	-3.2	1.0	5.7	-2.1	6.7	6.7	100
185	25-Aug-99	0.220	1.4	2.5	-1.4	-5.7	4.3	7.1	-0.7	7.4	7.4	100
186	26-Aug-99	0.220	2.1	0.7	-2.1	-4.4	3.7	7.1	-0.7	6.4	6.4	100
BATCH 13 Averages:		***0.220***	***0.7***	***3.2***	***-4.4***	***-4.4***	***4.8***	***8.3***	***0.3***	***8.5***	***8.5***	***100***
187	27-Aug-99											
188	28-Aug-99											
189	29-Aug-99	0.250	2.2	-9.9	-2.9	-3.9	17.8	4.4	-1.5	6.2	6.2	100
190	30-Aug-99	0.250	0.4	-8.4	-8.1	-1.3	6.6	19.1	2.2	12.5	12.5	100
191	31-Aug-99	0.250	2.2	-12.8	-4.4	-1.9	15.1	14.7	0.0	12.8	12.8	100
192	01-Sep-99	0.250	2.2	-11.4	-8.1	-3.2	15.7	13.2	0.0	8.4	8.4	100
193	02-Sep-99	0.250	2.2	-12.1	-5.9	-2.6	11.4	20.6	0.0	13.6	13.6	100
194	03-Sep-99	0.250	2.6	-11.0	-2.9	-5.8	11.7	16.2	-0.7	9.9	9.9	100
195	04-Sep-99											
196	05-Sep-99	0.250	3.3	-14.0	-6.6	-2.6	14.3	8.8	-1.5	1.8	1.8	100
197	06-Sep-99	0.250	5.9	-10.3	-8.1	-3.9	17.8	5.9	-3.7	3.7	3.7	100

Day No.	Date	EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
198	07-Sep-99	0.250	3.3	-10.3	-5.9	-4.5	11.8	11.7	1.5	7.7	7.7	100
199	08-Sep-99	0.250	1.8	-1.8	-6.6	-5.1	11.7	4.4	0.7	5.1	5.1	100
200	09-Sep-99	0.250	2.2	7.7	-12.5	-5.1	5.9	5.9	2.2	6.2	6.2	100
201	10-Sep-99	0.250	2.6	2.6	-7.3	-3.9	8.3	1.5	2.2	5.9	5.9	100
202	11-Sep-99											
203	12-Sep-99											
BATCH 14 Averages:		***0.250***	***2.6***	***-7.6***	***-8.8***	***-3.6***	***12.5***	***10.5***	***0.1***	***7.8***	***7.8***	***100***
204	13-Sep-99											
205	14-Sep-99											
206	15-Sep-99											
207	16-Sep-99	0.250	1.5	4.6	-6.8	1.3	6.3	1.5	2.3	10.7	10.7	100
208	17-Sep-99											
209	18-Sep-99											
210	19-Sep-99	0.250	0.8	0.0	-7.6	-5.3	11.4	9.1	3.0	11.4	11.4	100
211	20-Sep-99	0.250	1.9	-11.8	-4.6	-2.7	11.8	7.6	0.0	2.3	2.3	100
212	21-Sep-99	0.250	0.0	-1.1	-6.8	-4.7	13.8	12.2	5.3	18.6	18.6	100
213	22-Sep-99	0.250	0.4	-3.4	-7.6	-8.0	17.9	9.1	5.3	13.7	13.7	100
214	23-Sep-99											
215	24-Sep-99											
216	25-Sep-99											
BATCH 15 Averages:		***0.250***	***0.9***	***-2.4***	***-6.7***	***-3.9***	***12.2***	***7.9***	***3.2***	***11.3***	***11.3***	***100***
217	26-Sep-99											
218	27-Sep-99											
219	28-Sep-99	0.320	3.8	-8.3	-6.0	-2.5	12.3	15.0	-3.8	10.5	10.5	100
220	29-Sep-99	0.320	1.5	-11.6	-5.3	-0.6	14.9	13.5	-1.5	10.9	10.9	100
221	30-Sep-99	0.320	-1.1	-14.7	-1.5	-1.3	17.0	13.5	-0.8	11.3	11.3	100
222	01-Oct-99	0.320	-0.4	-15.0	-3.0	-2.5	17.6	13.5	1.5	11.6	11.6	100
223	02-Oct-99											
224	03-Oct-99	0.320	2.3	-21.0	-4.5	-1.9	19.2	13.5	-0.8	6.8	6.8	100
225	04-Oct-99	0.320	3.0	-21.1	-3.8	-2.5	20.6	12.0	0.0	8.3	8.3	100
226	05-Oct-99	0.320	1.5	-21.8	-3.8	-0.6	15.7	19.6	0.8	11.3	11.3	100
227	06-Oct-99	0.320	3.0	-22.2	-2.3	-1.9	17.0	16.6	0.0	10.2	10.2	100
228	07-Oct-99	0.320	4.1	-21.5	-3.8	-2.5	21.4	13.6	-1.5	9.8	9.8	100
229	08-Oct-99	0.320	2.3	-17.7	-5.3	-5.1	19.4	15.1	3.8	12.4	12.4	100
230	09-Oct-99											
231	10-Oct-99											
BATCH 16 Averages:		***0.320***	***2.0***	***-17.5***	***-3.9***	***-2.1***	***17.5***	***14.6***	***-0.2***	***10.3***	***10.3***	***100***
232	11-Oct-99											
233	12-Oct-99											
234	13-Oct-99	0.320	2.3	-17.7	-5.4	-6.5	17.2	16.9	-1.5	5.4	5.4	100
235	14-Oct-99	0.320	2.3	-16.5	-1.5	-6.5	17.2	13.8	0.8	9.6	9.6	100
236	15-Oct-99	0.320	1.9	-11.9	-1.5	-8.4	14.5	10.6	3.8	9.2	9.2	100
237	16-Oct-99											
238	17-Oct-99	0.320	3.5	-15.0	-1.5	-4.5	11.4	12.3	1.5	7.7	7.7	100
239	18-Oct-99											
240	19-Oct-99	0.320	1.9	-16.9	-4.6	-4.5	19.9	10.8	2.3	6.8	8.8	100
241	20-Oct-99	0.320	2.1	-20.1	-4.2	-2.4	20.7	11.3	2.1	9.5	9.5	100
242	21-Oct-99	0.320	3.5	-6.0	-4.2	-6.3	11.0	8.4	-0.7	6.7	6.7	100
243	22-Oct-99	0.320	3.5	-5.3	-4.9	-6.5	9.3	8.4	0.7	5.3	5.3	100
244	23-Oct-99											
245	24-Oct-99	0.320	2.5	-3.5	-3.5	-5.9	8.0	7.0	0.7	5.3	5.3	100
BATCH 17 Averages:		***0.320***	***2.6***	***-12.5***	***-3.5***	***-5.6***	***14.4***	***11.1***	***1.1***	***7.5***	***7.5***	***100***
246	25-Oct-99											
247	26-Oct-99											
248	27-Oct-99											
249	28-Oct-99	0.320	1.1	-19.7	-5.6	-1.2	19.5	15.5	-2.8	6.7	6.7	100
250	29-Oct-99	0.320	1.8	-16.5	0.0	-7.1	18.4	11.3	-0.7	7.0	7.0	100
251	30-Oct-99											
252	31-Oct-99	0.320	0.4	-18.1	-2.1	-3.0	20.0	11.3	0.0	8.5	8.5	100
253	01-Nov-99	0.320	0.4	-15.9	0.0	-1.2	16.1	11.3	0.0	10.6	10.6	100
254	02-Nov-99	0.320	-1.8	-16.3	-2.8	-3.0	17.9	17.0	1.4	12.4	12.4	100
255	03-Nov-99	0.320	-0.7	-19.5	-5.0	0.0	19.1	18.4	0.0	12.4	12.4	100
256	04-Nov-99	0.320	-1.4	-15.9	-4.3	-2.4	22.2	12.8	2.1	13.1	13.1	100
257	05-Nov-99											
258	06-Nov-99											
259	07-Nov-99	0.320	-0.7	-12.0	-3.5	-4.2	17.6	11.3	1.4	9.9	9.9	100
BATCH 18 Averages:		***0.320***	***-0.1***	***-16.8***	***-2.9***	***-2.7***	***18.8***	***13.6***	***0.2***	***10.1***	***10.1***	***100***
260	08-Nov-99											
261	09-Nov-99											
262	10-Nov-99											

Day No.	Date	EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
263	11-Nov-99	0.320	1.4	-4.6	-12.0	-5.3	14.5	12.7	2.1	8.8	8.8	100
264	12-Nov-99	0.320	0.7	-8.5	-3.5	-4.8	11.8	9.9	2.8	8.5	8.5	100
265	13-Nov-99											
266	14-Nov-99	0.320	2.1	-10.3	-4.2	-7.7	11.3	8.5	-0.7	-1.1	-1.1	100
267	15-Nov-99	0.320	1.1	-9.6	-3.5	-5.9	13.7	14.1	2.1	12.0	12.0	100
268	16-Nov-99											
269	17-Nov-99	0.320	3.1	-10.1	-6.3	-5.8	17.7	4.2	2.1	4.9	4.9	100
270	18-Nov-99	0.320	3.5	-7.3	-5.6	-5.3	10.8	7.0	-0.7	2.4	2.4	100
271	19-Nov-99	0.320	1.4	-3.1	-6.3	-5.3	12.2	5.6	3.5	8.0	8.0	100
BATCH 19 Averages:		***0.320***	***1.9***	***-7.6***	***-5.9***	***-5.7***	***13.2***	***8.9***	***1.6***	***6.2***	***6.2***	***100***
272	20-Nov-99											
273	21-Nov-99	0.320	-0.7	-12.5	-4.2	-2.3	19.0	12.5	0.7	12.5	12.5	100
274	22-Nov-99	0.320	0.3	-15.0	-4.2	-2.3	18.3	8.4	2.8	8.4	8.4	100
275	23-Nov-99	0.320	-3.8	-10.0	-4.1	-2.9	19.4	11.0	4.1	13.8	13.8	100
276	24-Nov-99	0.320	-1.0	-18.6	-2.1	-2.3	16.1	15.1	0.7	7.9	7.9	100
277	25-Nov-99	0.320	-1.0	-15.5	-4.8	-2.9	17.3	15.1	1.4	9.6	9.6	100
278	26-Nov-99											
279	27-Nov-99											
280	28-Nov-99	0.320	-2.1	-7.6	-2.8	-5.8	12.0	12.4	3.4	9.6	9.6	100
281	29-Nov-99											
282	30-Nov-99	0.320	-1.5	-14.0	-5.1	-4.3	15.3	19.1	0.0	9.6	9.6	100
283	01-Dec-99	0.320	-1.1	-10.7	-5.1	-5.6	18.1	16.2	0.7	12.5	12.5	100
284	02-Dec-99	0.320	-0.7	-10.3	-3.7	-6.2	16.5	13.2	0.7	9.6	9.6	100
BATCH 20 Averages:		***0.320***	***-1.3***	***-12.7***	***-4.0***	***-3.8***	***16.9***	***13.7***	***1.6***	***10.4***	***10.4***	***100***
285	03-Dec-99											
286	04-Dec-99											
287	05-Dec-99	0.320	-1.8	-11.4	-2.9	-5.6	15.8	16.2	2.9	13.2	13.2	100
288	06-Dec-99	0.320	-0.7	-13.2	-2.9	-5.6	17.3	14.7	0.7	10.3	10.3	100
289	07-Dec-99	0.320	-1.7	-10.8	-3.5	-4.7	12.4	16.7	0.7	9.1	9.1	100
290	08-Dec-99	0.320	-1.7	-12.2	-3.5	-4.1	13.9	13.3	2.8	8.4	8.4	100
291	09-Dec-99	0.320	-1.4	-12.8	-0.7	-4.7	11.7	16.7	1.4	10.5	10.5	100
292	10-Dec-99											
293	11-Dec-99											
294	12-Dec-99	0.320	0.0	-14.0	-2.8	-4.7	11.7	19.5	-2.1	7.7	7.7	100
295	13-Dec-99	0.320	-0.7	-11.0	-3.4	-7.5	10.2	22.6	0.0	10.3	10.3	100
296	14-Dec-99											
BATCH 21 Averages:		***0.320***	***-1.2***	***-12.2***	***-2.8***	***-5.3***	***13.3***	***17.1***	***0.9***	***9.9***	***9.9***	***100***
297	15-Dec-99											
298	16-Dec-99											
299	17-Dec-99	0.320	-4.8	-7.5	-6.2	-5.8	17.4	11.7	8.2	13.0	13.0	100
300	18-Dec-99											
301	19-Dec-99	0.320	1.7	-12.7	-4.1	-4.6	17.7	8.2	2.1	8.2	8.2	100
302	20-Dec-99	0.320	0.7	-11.7	-6.2	-1.7	15.5	10.3	1.4	8.2	8.2	100
303	21-Dec-99	0.320	1.0	-16.1	-2.1	-5.8	19.5	8.2	2.1	6.9	6.9	100
304	22-Dec-99	0.320	2.8	-14.5	-6.2	-4.6	21.9	9.0	1.4	9.7	9.7	100
305	23-Dec-99	0.320	1.7	-17.0	-3.5	-5.8	21.7	9.0	2.8	9.0	9.0	100
306	24-Dec-99											
307	25-Dec-99											
308	26-Dec-99	0.320	2.1	-11.4	-5.5	-4.6	17.1	11.1	0.7	9.3	9.3	100
309	27-Dec-99	0.320	2.1	-18.3	-4.2	-5.2	19.1	10.4	2.8	8.6	8.6	100
310	28-Dec-99	0.320	1.4	-13.1	-3.5	-7.0	17.4	11.8	2.8	9.7	9.7	100
311	29-Dec-99	0.320	1.4	-13.5	-2.8	-5.8	15.5	13.1	2.1	10.0	10.0	100
BATCH 22 Averages:		***0.320***	***1.0***	***-13.4***	***-4.4***	***-5.1***	***18.3***	***10.3***	***2.6***	***9.3***	***9.3***	***100***
312	30-Dec-99											
313	31-Dec-99											
314	01-Jan-00											
315	02-Jan-00	0.320	0.6	-2.2	-3.2	-3.7	8.1	6.3	2.5	8.5	8.5	100
316	03-Jan-00	0.320	0.6	2.2	-3.2	-6.9	8.2	2.5	2.5	6.0	6.0	100
317	04-Jan-00	0.320	1.3	-12.0	-4.4	-4.8	17.4	7.0	1.3	5.7	5.7	100
318	05-Jan-00	0.320	0.9	-15.8	-3.2	-1.1	15.6	7.6	1.3	5.4	5.4	100
319	06-Jan-00	0.320	1.6	-13.6	-3.8	-1.6	16.8	4.4	0.6	4.4	4.4	100
320	07-Jan-00	0.320	1.6	-16.8	-0.6	-1.1	16.2	6.3	0.0	5.7	5.7	100
321	08-Jan-00											
322	09-Jan-00											
323	10-Jan-00	0.320	0.9	-13.7	-3.0	-2.6	16.6	7.9	0.0	6.1	6.1	100
324	11-Jan-00	0.320	2.1	-14.0	-2.4	-1.0	15.0	6.7	-0.6	5.8	5.8	100
325	12-Jan-00	0.320	3.0	-9.7	0.0	-6.1	11.8	7.3	-1.2	4.9	4.9	100
326	13-Jan-00	0.320	1.8	-4.3	-3.0	-5.1	11.2	6.1	-1.2	5.5	5.5	100
327	14-Jan-00	0.320	1.8	-11.3	-2.4	-5.1	17.9	12.2	-0.6	12.5	12.5	100
BATCH 23 Averages:		***0.320***	***1.5***	***-10.1***	***-2.7***	***-3.6***	***14.1***	***6.8***	***0.4***	***6.4***	***6.4***	***100***

Day No.	Date	EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
328	15-Jan-00											
329	16-Jan-00	0.320	1.2	-7.4	-3.1	-4.6	15.1	5.5	2.5	9.2	9.2	100
330	17-Jan-00	0.320	0.6	-4.6	-2.5	-4.6	12.6	6.1	1.8	9.5	9.5	100
331	18-Jan-00	0.320	0.3	-8.0	-4.3	-7.7	17.5	9.8	4.3	12.0	12.0	100
332	19-Jan-00	0.320	-1.8	-19.3	-5.5	-3.6	22.6	13.5	5.5	11.3	11.3	100
333	20-Jan-00	0.320	1.8	-13.2	-6.1	-6.2	18.5	11.7	1.8	8.3	8.3	100
334	21-Jan-00	0.320	1.2	-4.6	-3.1	-7.7	12.6	10.4	1.2	10.1	10.1	100
335	22-Jan-00											
336	23-Jan-00											
337	24-Jan-00	0.320	1.9	-12.9	-5.7	-5.8	20.3	9.4	1.3	8.5	8.5	100
338	25-Jan-00	0.320	1.6	-14.2	-6.9	-7.4	23.1	11.3	1.9	9.4	9.4	100
339	26-Jan-00	0.320	1.6	-13.8	-6.3	-6.9	22.6	11.3	1.3	9.7	9.7	100
340	27-Jan-00											
341	28-Jan-00											
BATCH 24 Averages:		***0.320***	***0.9***	***-10.9***	***-4.8***	***-6.1***	***18.3***	***9.9***	***2.4***	***9.8***	***9.8***	***100***
342	29-Jan-00											
343	30-Jan-00											
344	31-Jan-00	0.320	0.3	-15.1	-6.3	-2.1	19.1	10.7	1.9	8.5	8.5	100
345	01-Feb-00	0.320	-0.6	-18.6	-4.4	-4.8	22.4	15.7	1.9	11.6	11.6	100
346	02-Feb-00											
347	03-Feb-00	0.320	-3.8	-18.9	-5.7	-4.2	23.7	20.1	0.6	11.9	11.9	100
348	04-Feb-00	0.320	-3.8	-13.5	-6.3	-5.8	20.2	20.1	1.3	12.2	12.2	100
349	05-Feb-00											
350	06-Feb-00	0.320	-1.3	-15.7	-3.8	-5.3	20.3	15.0	-1.3	8.2	8.2	100
351	07-Feb-00	0.320	-2.8	-19.1	-0.6	-5.3	23.4	16.9	0.6	13.2	13.2	100
352	08-Feb-00	0.320	-2.2	-18.5	-3.1	-4.2	18.6	21.3	-0.6	11.3	11.3	100
353	09-Feb-00	0.320	-3.1	-19.4	-3.8	-4.7	22.9	20.1	-0.6	11.3	11.3	100
354	10-Feb-00	0.320	-0.9	-21.6	-5.0	-4.7	21.7	23.8	-3.8	9.4	9.4	100
355	11-Feb-00											
BATCH 25 Averages:		***0.320***	***-2.0***	***-17.8***	***-4.3***	***-4.6***	***21.4***	***18.2***	***0.0***	***10.8***	***10.8***	***100***
356	12-Feb-00											
357	13-Feb-00											
358	14-Feb-00	0.320	-1.6	-11.0	-3.2	-7.0	19.9	11.6	1.9	10.6	10.6	100
359	15-Feb-00	0.320	-1.3	-24.2	-3.2	-5.4	31.9	14.2	1.9	13.9	13.9	100
360	16-Feb-00	0.320	-0.3	-26.5	-3.9	-7.6	33.4	16.8	0.0	11.9	11.9	100
361	17-Feb-00	0.320	-1.0	-33.9	-2.6	-3.3	37.4	16.8	-1.3	12.3	12.3	100
362	18-Feb-00											
363	19-Feb-00											
364	20-Feb-00	0.320	-2.6	-28.1	-7.1	-0.5	32.2	19.4	1.3	14.5	14.5	100
365	21-Feb-00	0.320	-3.1	-27.3	-6.2	-4.7	38.8	19.9	3.1	20.5	20.5	100
366	22-Feb-00	0.320	-1.2	-31.0	-3.7	-2.6	36.1	17.4	-1.9	13.0	13.0	100
367	23-Feb-00	0.320	-2.2	-28.9	-6.8	-1.0	37.7	19.2	1.2	19.2	19.2	100
368	24-Feb-00	0.320	-3.4	-25.1	-5.0	-3.6	29.7	15.5	4.3	12.4	12.4	100
BATCH 26 Averages:		***0.320***	***-1.9***	***-26.2***	***-4.6***	***-4.0***	***33.0***	***16.7***	***1.2***	***14.3***	***14.3***	***100***
369	25-Feb-00											
370	26-Feb-00											
371	27-Feb-00	0.320	0.0	-11.5	-6.2	-5.2	17.6	13.0	-1.9	5.9	5.9	100
372	28-Feb-00	0.320	-0.6	-14.0	-8.7	-5.7	24.4	13.7	-3.1	5.9	5.9	100
373	29-Feb-00	0.320	-0.3	-19.0	-6.9	-5.2	28.3	11.8	0.6	9.3	9.3	100
374	01-Mar-00	0.320	-0.3	-15.6	-4.4	-6.8	25.5	10.6	0.0	9.0	9.0	100
375	02-Mar-00	0.320	-0.9	-16.2	-7.5	-5.2	29.5	10.0	1.2	10.9	10.9	100
376	03-Mar-00	0.320										
377	04-Mar-00	0.320										
378	05-Mar-00	0.320	-0.9	-19.0	-3.1	-6.3	29.3	10.0	0.0	10.0	10.0	100
379	06-Mar-00	0.320	-0.6	-19.5	-5.6	-5.7	28.0	10.5	3.1	10.2	10.2	100
380	07-Mar-00	0.320	0.3	-17.6	-8.2	-7.3	27.7	13.0	0.6	10.5	10.5	100
381	08-Mar-00											
382	09-Mar-00											
BATCH 27 Averages:		***0.320***	***-0.4***	***-16.5***	***-6.1***	***-5.9***	***26.3***	***11.6***	***0.1***	***9.0***	***9.0***	***100***
383	10-Mar-00											
384	11-Mar-00											
385	12-Mar-00	0.310	3.4	-13.3	-5.6	-4.7	20.1	8.0	1.2	9.3	9.3	100
386	13-Mar-00	0.310	1.5	-23.8	-4.3	-3.1	28.5	10.5	1.9	11.1	11.1	100
387	14-Mar-00	0.310	1.6	-25.4	-3.9	-6.0	39.2	7.2	1.3	14.0	14.0	100
388	15-Mar-00	0.310	1.3	-24.1	-3.9	-4.9	32.3	11.1	-0.7	11.1	11.1	100
389	16-Mar-00	0.310	-1.0	-26.7	-2.6	-3.8	34.4	10.4	1.3	12.0	12.0	100
390	17-Mar-00											
391	18-Mar-00											
392	19-Mar-00	0.310	1.3	-17.2	-3.3	-6.0	23.6	9.1	0.7	8.1	8.1	100
393	20-Mar-00	0.310	1.9	-13.8	-5.1	-8.1	24.7	9.0	1.3	9.9	9.9	100

[illegible]		EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
Day No.	Date											
394	21-Mar-00	0.310	1.9	-17.0	-4.5	-5.9	23.9	9.0	0.6	8.0	8.0	100
395	22-Mar-00	0.310	1.0	-17.9	-3.8	-7.0	24.9	8.3	3.8	9.3	9.3	100
396	23-Mar-00											
397	24-Mar-00											
BATCH 28 Averages:		***0.310***	***1.4***	***-19.9***	***-4.1***	***-5.5***	***28.0***	***9.2***	***1.3***	***10.3***	***10.3***	***100***
398	25-Mar-00											
399	26-Mar-00	0.310	0.0	-18.9	-2.6	-5.9	24.5	11.5	0.0	8.6	8.6	100
400	27-Mar-00	0.310	0.3	-21.3	-5.7	-5.4	27.7	14.6	1.3	11.5	11.5	100
401	28-Mar-00	0.310	-0.3	-26.7	-3.2	-3.2	28.7	13.4	3.2	11.8	11.8	100
402	29-Mar-00	0.310	0.6	-25.1	-3.8	-5.4	31.5	14.0	-1.3	10.5	10.5	100
403	30-Mar-00	0.310	0.0	-27.1	-1.9	-3.8	29.2	14.6	0.6	11.8	11.8	100
404	31-Mar-00											
405	01-Apr-00											
406	02-Apr-00	0.310	0.3	-6.7	-1.9	-7.0	20.4	8.3	-0.6	12.7	12.7	100
407	03-Apr-00	0.310	-1.6	-17.8	-5.7	-5.9	25.6	17.2	1.3	13.0	13.0	100
BATCH 29 Averages:		***0.310***	***-0.1***	***-20.5***	***-3.5***	***-5.2***	***26.8***	***13.4***	***0.6***	***11.4***	***11.4***	***100***
408	04-Apr-00											
409	05-Apr-00											
410	06-Apr-00	0.310	-1.0	-22.9	-2.5	-5.4	27.0	17.2	2.5	14.9	14.9	100
411	07-Apr-00											
412	08-Apr-00											
413	09-Apr-00	0.310	0.0	-14.3	-3.8	-6.4	19.1	14.0	2.5	11.1	11.1	100
414	10-Apr-00	0.310	1.0	-22.6	-4.4	-6.4	24.9	15.9	1.3	9.5	9.5	100
415	11-Apr-00	0.270	2.3	-21.5	-2.6	-7.3	26.2	16.3	0.7	14.0	14.0	100
416	12-Apr-00	0.270	1.6	-22.5	-2.6	-6.8	26.3	16.3	2.0	14.3	14.3	100
417	13-Apr-00	0.270	1.6	-19.6	-4.6	-5.1	24.6	17.0	3.9	17.9	17.9	100
418	14-Apr-00											
419	15-Apr-00											
420	16-Apr-00	0.270	1.3	-14.7	-3.3	-5.1	20.1	13.0	2.0	13.4	13.4	100
421	17-Apr-00											
BATCH 30 Averages:		***0.287***	***1.0***	***-19.7***	***-3.4***	***-6.1***	***24.0***	***15.7***	***2.1***	***13.6***	***13.6***	***100***
422	18-Apr-00											
423	19-Apr-00											
424	20-Apr-00											
425	21-Apr-00											
426	22-Apr-00											
427	23-Apr-00											
428	24-Apr-00	0.314	1.6	-15.5	-3.2	-2.7	21.5	19.4	-6.5	14.6	14.6	100
429	25-Apr-00	0.314	-5.5	-20.1	-2.6	-3.3	25.3	14.9	8.4	17.1	17.1	100
430	26-Apr-00	0.314	-4.9	-12.3	-7.1	-6.5	24.0	22.0	3.2	18.4	18.4	100
431	27-Apr-00	0.314	-6.5	-11.6	-5.8	-8.2	21.8	25.2	3.2	18.1	18.1	100
432	28-Apr-00	0.314	-6.5	-19.1	-5.2	-5.5	24.2	25.9	5.2	19.1	19.1	100
433	29-Apr-00											
434	30-Apr-00	0.314	-3.9	-12.6	-3.2	-6.0	18.3	22.0	2.6	17.1	17.1	100
435	01-May-00	0.314	-3.1	-23.0	-2.8	-3.3	22.9	20.2	2.8	13.7	13.7	100
436	02-May-00	0.314	-3.1	-23.2	-3.4	-4.3	23.3	19.6	3.4	12.3	12.3	100
437	03-May-00	0.314	-2.8	-21.6	-3.4	-2.8	19.1	22.4	1.1	12.0	12.0	100
438	04-May-00	0.314	-1.7	-20.2	-5.0	-3.8	20.8	21.3	1.1	12.3	12.3	100
BATCH 31 Averages:		***0.314***	***-3.6***	***-17.9***	***-4.2***	***-4.6***	***22.1***	***21.3***	***2.5***	***15.5***	***15.5***	***100***
439	05-May-00											
440	06-May-00											
441	07-May-00											
442	08-May-00	0.314	-2.5	-33.9	-3.9	-3.3	30.2	25.2	2.8	14.8	14.6	100
443	09-May-00	0.368	3.4	-25.1	-5.5	-2.0	22.8	18.4	0.0	11.9	11.9	100
444	10-May-00	0.368	-7.7	-16.9	-2.5	-6.5	26.1	22.1	0.6	15.3	15.3	100
445	11-May-00	0.368	-1.2	-27.9	-3.7	-4.5	25.9	22.1	4.3	15.0	15.0	100
446	12-May-00	0.368	-0.9	-23.9	-3.1	-6.0	26.2	22.1	0.6	15.0	15.0	100
447	13-May-00											
448	14-May-00	0.368	-2.1	-28.5	-3.7	-5.5	23.3	23.3	3.1	9.8	9.8	100
449	15-May-00	0.368	4.3	-27.3	-4.9	-3.0	23.2	18.4	-0.6	10.1	10.1	100
450	16-May-00	0.368										
451	17-May-00	0.368	3.1	-19.1	-3.1	-3.1	20.0	15.1	-1.3	11.8	11.6	100
452	18-May-00	0.368	1.3	-16.9	-5.0	-4.6	18.4	14.4	3.8	11.3	11.3	100
453	19-May-00	0.368										
454	20-May-00	0.368										
455	21-May-00	0.388	-0.3	-17.3	0.0	-5.8	20.7	14.4	-1.9	10.0	10.0	100
456	22-May-00											
BATCH 32 Averages:		***0.364***	***-0.3***	***-23.7***	***-3.5***	***-4.4***	***23.7***	***19.5***	***1.1***	***12.5***	***12.5***	***100***
457	23-May-00											
458	24-May-00											

Day No.	Date	EN Sludge Bypass l/d infl.	Δ PreANO mgP/l infl.	Δ AN mgP/l infl.	Δ SETA mgP/l infl.	Δ SETB(+Nit.) mgP/l infl.	Δ ANO mgP/l infl.	Δ AE mgP/l infl.	Δ Fin. SET mgP/l infl.	ΣΔ	Influent minus effluent	% Recovery
459	25-May-00											
460	26-May-00											
461	27-May-00											
462	28-May-00											
463	29-May-00											
464	30-May-00											
465	31-May-00											
466	01-Jun-00											
467	02-Jun-00											
468	03-Jun-00											
469	04-Jun-00											
470	05-Jun-00											
BATCH 33 Averages:												
471	06-Jun-00											
472	07-Jun-00											
473	08-Jun-00											
474	09-Jun-00											
475	10-Jun-00											
476	11-Jun-00	0.368	1.3	-2.5	-3.1	-5.1	10.8	6.3	3.8	11.3	11.3	100
477	12-Jun-00	0.368	2.5	-10.1	-4.4	-4.6	13.4	10.1	1.9	8.8	8.8	100
478	13-Jun-00	0.368	3.1	-15.1	-2.5	-3.1	15.0	10.1	0.0	7.6	7.6	100
479	14-Jun-00	0.368	2.5	-6.6	-3.8	-4.6	11.5	10.1	0.6	9.8	9.8	100
480	15-Jun-00	0.368	2.5	-6.3	-3.8	-4.1	10.4	8.2	1.3	8.2	8.2	100
481	16-Jun-00	0.368	1.9	-5.7	-3.8	-2.6	10.1	5.0	3.1	8.2	8.2	100
482	17-Jun-00											
483	18-Jun-00	0.368	0.9	2.5	-2.5	-4.6	4.0	5.0	1.3	6.6	6.6	100
BATCH 34 Averages:		***0.368***	***2.1***	***-6.3***	***-3.4***	***-4.1***	***10.8***	***7.8***	***1.7***	***8.6***	***8.6***	***100***

		EN Sludge	NITRITE							NITRATE						
		Bypass	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET
Day No.	Date	l/d infl.	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d
1	22-Feb-99	0.083	1.3	-1.3	-0.8	-77.2	87.3	-26.8	13.7	41.4	24.8	4.3	-180.4	312.3	-282.0	2.0
2	23-Feb-99	0.083	1.0	-1.6	1.6	-94.8	83.5	-2.1	8.8	17.9	41.2	2.2	-211.6	330.5	-293.1	41.0
3	24-Feb-99	0.083	1.0	-4.0	3.8	-130.1	121.8	1.0	3.4	39.7	37.0	10.9	-388.4	444.4	-224.3	-14.5
4	25-Feb-99	0.083	0.3	-3.8	2.5	-139.2	140.8	-7.2	4.4	32.8	9.2	13.5	-484.3	591.5	-260.8	34.3
5	26-Feb-99															
6	27-Feb-99															
7	28-Feb-99															
8	01-Mar-99	0.083	4.1	-4.9	3.9	-55.3	33.7	16.5	-2.9	1.2	3.3	16.3	-642.3	675.0	-222.3	133.0
9	02-Mar-99	0.083	-0.8	1.5	0.0	-21.9	1.1	13.4	3.9	3.2	-11.1	13.2	-840.0	540.2	-104.7	177.8
10	03-Mar-99															
11	04-Mar-99															
BATCH 1 Averages:		***0.083***	***1.2***	***-2.4***	***1.8***	***-86.4***	***78.0***	***-0.9***	***5.2***	***22.7***	***17.4***	***10.1***	***-424.5***	***482.3***	***-231.2***	***62.3***
12	05-Mar-99															
13	06-Mar-99															
14	07-Mar-99															
15	08-Mar-99															
BATCH 2 Averages:		***Bad Batch***														
16	09-Mar-99															
17	10-Mar-99															
18	11-Mar-99															
19	12-Mar-99															
20	13-Mar-99															
21	14-Mar-99															
22	15-Mar-99															
23	16-Mar-99															
24	17-Mar-99															
25	18-Mar-99															
BATCH 3 Averages:																
26	19-Mar-99															
27	20-Mar-99															
28	21-Mar-99															
29	22-Mar-99	0.083	-25.7	38.8	-0.1	-19.2	-100.4	84.2	6.8	178.0	130.8	-2.1	-487.6	384.0	-380.9	-132.5
30	23-Mar-99	0.083	-16.4	27.5	0.8	-28.1	-97.7	94.4	5.9	126.7	101.0	0.2	-524.6	338.5	-190.7	-82.0
31	24-Mar-99															
32	25-Mar-99	0.083	-14.4	26.8	0.5	-44.9	-26.6	28.7	13.7	115.6	96.3	1.3	-540.9	578.7	-505.9	32.1
33	26-Mar-99															
34	27-Mar-99															
35	28-Mar-99															
36	29-Mar-99															
37	30-Mar-99															
38	31-Mar-99															
BATCH 4 Averages:		***0.083***	***-18.8***	***31.0***	***0.4***	***-30.7***	***-74.9***	***69.1***	***8.8***	***140.1***	***109.3***	***-0.2***	***-511.0***	***427.1***	***-359.2***	***-60.8***
39	01-Apr-99															
40	02-Apr-99															
41	03-Apr-99															
42	04-Apr-99															
43	05-Apr-99	0.083	-18.0	18.1	0.1	-104.9	-4.5	90.1	15.0	57.6	192.7	7.3	-646.3	273.2	-263.6	108.3
44	06-Apr-99															
45	07-Apr-99															
46	08-Apr-99															
47	09-Apr-99															
48	10-Apr-99															
49	11-Apr-99	0.083	-9.6	20.5	3.4	-40.1	-31.0	31.5	7.5	129.5	120.7	17.8	-396.8	121.9	-210.2	-58.4
50	12-Apr-99	0.083	-4.5	22.6	-0.1	-113.3	5.2	87.5	1.1	60.7	208.6	4.2	-667.7	116.7	-1.2	-3.5
51	13-Apr-99	0.083	1.7	18.9	0.0	-104.4	27.0	40.5	-7.5	85.3	164.9	8.2	-525.8	252.0	-183.5	-84.7
52	14-Apr-99															
53	15-Apr-99	0.083	0.6	37.1	2.5	-100.0	39.6	-22.5	1.1	42.8	244.2	10.0	-689.3	370.4	-227.6	-52.0
54	16-Apr-99															
BATCH 5 Averages:		***0.083***	***-6.0***	***23.5***	***1.2***	***-92.6***	***7.2***	***41.4***	***3.4***	***77.2***	***186.2***	***9.7***	***-585.2***	***226.8***	***-177.2***	***-18.5***
55	17-Apr-99															
56	18-Apr-99															
57	19-Apr-99	0.083	17.1	0.0	-1.3	1.2	-89.8	12.8	40.6	124.8	5.2	13.6	-561.9	552.6	-258.7	-27.2
58	20-Apr-99															
59	21-Apr-99															
60	22-Apr-99	0.083	0.0	0.0	-1.3	1.2	-34.2	-124.1	150.4	180.9	8.5	6.0	-455.8	506.3	-268.4	-170.6
61	23-Apr-99															
62	24-Apr-99															
63	25-Apr-99															
64	26-Apr-99															
65	27-Apr-99	0.083	0.0	-3.9	0.6	-50.2	-25.7	-102.7	172.7	205.7	14.3	-2.1	-626.9	620.6	-143.2	-280.6
66	28-Apr-99	0.083	77.0	-3.9	0.9	-21.7	165.9	-282.4	-12.2	64.9	9.5	-0.9	-493.6	407.8	-152.7	79.6
67	29-Apr-99	0.083	56.8	-4.3	-0.2	-26.5	-232.3	265.3	-111.8	112.6	12.6	-0.7	-738.9	906.0	-478.1	61.1
BATCH 6 Averages:		***0.083***	***30.8***	***-2.4***	***-0.3***	***-19.8***	***-43.2***	***-46.2***	***48.0***	***137.8***	***10.0***	***3.2***	***-578.4***	***598.6***	***-260.2***	***-69.6***
68	30-Apr-99															
69	01-May-99															
70	02-May-99															
71	03-May-99	0.083	5.7	0.5	0.3	-24.7	-42.0	40.9	10.8	58.4	-3.7	-1.6	-488.4	421.8	-45.2	-4.8
72	04-May-99	0.083	4.5	-0.1	0.8	-19.2	-207.6	185.4	17.3	121.5	27.1	-2.8	-696.3	715.5	-173.7	-141.1
73	05-May-99	0.083	11.4	0.2	0.2	-14.6	-171.1	140.9	17.3	103.8	20.6	-0.7	-715.2	676.2	-145.2	-68.9
74	06-May-99	0.083	11.4	-0.7	0.7	-19.6	-134.9	122.7	6.5	43.0	34.6	-2.9	-702.3	727.3	-179.2	-4.4
75	07-May-99	0.083	1.7	6.6	0.7	-20.0	-114.5	113.6	1.1	85.2	-6.2	4.1	-636.9	657.5	-187.5	-7.3
76	08-May-99															
77	09-May-99	0.083	9.7	4.9	1.9	-12.4	-97.9	82.8	-6.9	-9.7	61.6	1.1	-444.2	459.3	-165.2	36.3
78	10-May-99	0.083	6.5	-1.2	2.2	-9.1	-124.6	107.1	4.6	-0.8	59.9	0.4	-553.1	568.9	-163.8	19.8
79	11-May-99	0.083	7.3	4.9	3.2	-20.5	-144.6	116.9	13.9	49.3	33.8	6.1	-602.9	537.3	-163.2	42.4
80	12-May-99	0.083	-6.1	21.4	2.7	-11.4	-139.3	107.1	4.6	96.2	10.0	5.0	-692.5	603.2	-168.9	29.6

Day No.	Date	EN Sludge Bypass l/d infl.	NITRITE Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ SETB+Nit mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ Fin. SET mgN/d	NITRATE Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ SETB+Nit mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ Fin. SET mgN/d
81	13-May-99	0.083	-7.3	20.5	1.6	-7.4	-119.6	90.1	4.6	94.9	20.2	4.9	-588.5	498.1	-157.0	2.7
82	14-May-99															
BATCH 7 Averages:		***0.083***	***4.7***	***5.7***	***1.5***	***-15.9***	***-129.6***	***111.8***	***7.4***	***64.2***	***25.8***	***1.4***	***-611.8***	***586.5***	***-154.9***	***-9.5***
83	15-May-99															
84	16-May-99	0.083	-17.0	32.1	4.4	-3.5	-73.2	26.8	6.9	163.8	31.7	13.6	-805.6	517.1	-124.6	-11.8
85	17-May-99	0.083	-33.1	64.1	6.1	-22.7	-74.9	-45.9	64.2	96.8	175.5	19.4	-769.5	-54.9	375.8	-132.9
86	18-May-99	0.083	-38.2	74.4	6.4	-22.5	-181.9	89.2	26.6	122.2	96.3	6.4	-821.9	648.9	-320.7	33.9
87	19-May-99															
88	20-May-99															
89	21-May-99															
90	22-May-99															
91	23-May-99															
92	24-May-99	0.083	-19.1	63.7	3.3	-45.9	-111.6	51.0	7.3	132.0	109.4	5.9	-911.1	579.5	-97.3	-67.7
93	25-May-99	0.083	-19.6	74.4	5.4	-50.8	-106.7	30.6	3.6	103.7	84.2	10.9	-940.6	636.8	-100.0	1.9
94	26-May-99	0.083	-15.3	61.2	4.6	-99.7	-91.0	56.1	29.1	133.9	52.9	5.3	-868.2	548.7	-163.4	-84.0
95	27-May-99	0.083	-19.1	81.9	5.6	-134.3	-21.1	30.6	24.2	121.9	10.7	7.1	-656.2	542.5	-169.5	-2.2
96	28-May-99															
97	29-May-99															
98	30-May-99															
BATCH 8 Averages:		***0.083***	***-23.1***	***61.7***	***5.1***	***-84.2***	***-94.3***	***34.0***	***23.1***	***124.9***	***80.1***	***9.8***	***-795.2***	***488.5***	***-88.5***	***-37.6***
99	31-May-99															
100	01-Jun-99															
101	02-Jun-99															
102	03-Jun-99															
BATCH 9 Averages:		***Bad Batch***														
103	04-Jun-99															
104	05-Jun-99															
105	06-Jun-99	0.100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.8	14.8	2.4	-162.2	127.1	-87.8	-79.6
106	07-Jun-99	0.100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.9	2.0	3.6	-162.6	187.0	-135.7	0.0
107	08-Jun-99	0.100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	21.1	2.8	-223.7	295.5	-163.6	19.0
108	09-Jun-99	0.100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	14.4	-0.4	-161.1	244.9	-195.5	39.6
109	10-Jun-99															
110	11-Jun-99															
111	12-Jun-99															
112	13-Jun-99															
113	14-Jun-99															
114	15-Jun-99															
115	16-Jun-99	0.150	35.9	5.2	-0.9	-50.5	120.9	-175.3	20.5	-0.1	4.4	-3.9	-78.4	94.4	-24.4	2.2
116	17-Jun-99	0.150	48.1	7.2	-1.6	-140.0	218.5	-189.6	0.0	1.8	0.8	-1.2	-13.4	29.5	-27.4	4.1
117	18-Jun-99															
118	19-Jun-99															
119	20-Jun-99	0.150	89.0	7.5	-0.3	-252.5	272.6	-206.9	30.0	7.0	-1.8	-1.0	17.6	10.1	-31.9	-7.3
120	21-Jun-99	0.150	69.0	7.5	-0.9	-299.8	214.2	-91.9	21.8	9.2	-2.3	-0.0	24.7	-10.7	-20.9	-9.5
121	22-Jun-99	0.150	44.5	8.0	-1.1	-92.8	179.2	-218.4	24.6	-20.7	28.4	-0.2	2.0	6.6	-24.8	-3.9
122	23-Jun-99	0.150	35.9	9.5	-2.3	-325.6	203.5	11.5	19.1	20.5	-3.4	0.6	10.3	35.8	-63.6	-19.1
123	24-Jun-99															
124	25-Jun-99															
125	26-Jun-99															
126	27-Jun-99															
127	28-Jun-99	0.150	20.6	-0.6	-23.4	-527.8	453.8	82.2	-24.0	17.4	5.2	-3.9	-3.5	19.3	-26.6	-33.6
128	29-Jun-99															
129	30-Jun-99	0.150	28.5	4.7	-0.6	-644.5	200.8	234.0	132.2	14.5	5.9	-0.4	-47.7	117.5	-122.7	7.2
130	01-Jul-99	0.150	12.7	-0.6	-1.9	-635.4	378.6	170.8	80.1	7.6	4.4	-0.9	-31.3	78.4	-79.7	4.8
131	02-Jul-99	0.150	19.0	-0.6	-1.3	-609.7	345.9	192.8	33.1	-2.5	19.1	-0.3	-39.0	51.8	-41.1	-9.0
132	03-Jul-99															
133	04-Jul-99															
134	05-Jul-99															
BATCH 10 Averages:		***0.138***	***27.4***	***3.4***	***-2.4***	***-255.6***	***184.8***	***-13.8***	***22.7***	***16.3***	***8.1***	***-0.2***	***-62.0***	***92.1***	***-74.7***	***-6.1***
135	06-Jul-99	0.185	7.9	75.3	-3.2	-909.3	445.0	-69.6	345.5	16.1	0.4	0.1	-26.8	82.0	-132.8	38.8
136	07-Jul-99	0.185	74.9	196.8	-7.2	-1158.0	386.0	122.6	97.1	14.7	35.7	-2.1	38.4	98.3	-265.0	25.7
137	08-Jul-99	0.185	132.8	150.2	-15.3	-1160.8	511.7	54.5	29.1	30.7	13.6	0.6	37.0	17.2	-170.5	21.0
138	09-Jul-99	0.185	139.6	128.4	-3.1	-1194.8	504.6	149.8	-6.5	50.2	24.9	-0.8	17.2	92.4	-255.3	-8.6
139	10-Jul-99	0.185	156.7	83.8	-8.5	-1086.8	406.9	218.0	-19.4	59.8	1.7	-1.5	-1.2	104.6	-270.7	39.5
140	11-Jul-99	0.185	105.6	47.0	-14.1	-955.4	352.1	282.7	19.4	81.7	32.6	-3.8	28.4	86.0	-293.2	-49.5
141	12-Jul-99															
142	13-Jul-99	0.185	64.1	29.2	1.9	-919.8	307.3	379.9	33.9	126.4	54.6	-1.9	-223.1	352.4	-487.2	-9.8
143	14-Jul-99	0.185	61.7	35.6	-2.1	-926.2	431.7	191.6	101.8	121.6	56.5	-23.9	-166.5	269.6	-440.0	0.1
144	15-Jul-99	0.185	74.7	24.0	-1.5	-362.3	281.3	-194.8	74.0	107.4	62.8	-0.2	-90.0	398.0	-668.8	14.4
145	16-Jul-99															
146	17-Jul-99															
147	18-Jul-99	0.185	81.2	124.7	-9.7	-316.5	232.4	-321.5	-1.5	79.7	56.5	-4.4	-173.2	338.6	-502.7	60.5
148	19-Jul-99	0.185	95.8	42.5	-7.1	-242.8	163.6	-155.9	-37.0	113.1	89.8	-1.9	-332.7	370.5	-487.7	37.0
149	20-Jul-99															
150	21-Jul-99	0.185	8.9	1.0	-5.9	-140.8	109.2	31.6	-14.1	171.5	65.3	-7.8	-556.0	264.6	245.3	-404.5
151	22-Jul-99	0.185	12.4	1.4	-1.8	-57.9	40.6	2.0	-11.3	-4.0	220.2	-1.7	-697.8	220.2	-35.5	69.1
152	23-Jul-99															
BATCH 11 Averages:		***0.185***	***78.2***	***72.4***	***-6.0***	***-725.5***	***321.0***	***53.1***	***47.0***	***74.5***	***55.0***	***-3.8***	***-165.4***	***207.2***	***-289.8***	***-13.0***
153	24-Jul-99															
154	25-Jul-99															
155	26-Jul-99	0.185	2.0	1.6	-1.0	-23.0	13.5	4.0	-1.9	-3.0	200.9	2.7	-671.6	138.1	17.0	101.5
156	27-Jul-99	0.185	1.0	1.6	-5.1	-19.2	11.9	4.0	1.9	59.9	202.1	-4.5	-814.8	201.0	38.0	44.0
157	28-Jul-99	0.220	0.5	1.8	-1.6	-11.6	6.5	7.9	-6.6	87.6	113.6	-1.4	-792.4	343.1	92.8	-49.2
158	29-Jul-99															
159	30-Jul-99	0.220	2.0	1.8	-0.6	-40.5	20.7	15.8	-3.8	48.4	149.5	-0.7	-636.2	237.6	-11.6	5.7
160	31-Jul-99															
161	01-Aug-99															

		EN Sludge	NITRITE							NITRATE						
		Bypass	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET
Day No.	Date	l/d Infl.	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d
162	02-Aug-99	0.220	30.3	6.4	0.0	-42.0	-14.7	49.3	-64.9	39.7	160.1	-0.3	-693.9	237.4	-89.4	128.3
163	03-Aug-99	0.220	-2.4	5.6	0.2	-32.6	-5.9	34.1	-3.6	102.5	132.6	1.1	-851.9	277.0	152.7	-59.8
164	04-Aug-99															
165	05-Aug-99	0.220	0.9	7.8	0.2	-51.0	22.1	-7.6	16.2	109.2	121.7	-2.9	-804.3	532.9	-99.2	-92.3
166	06-Aug-99	0.220	9.5	3.2	0.2	-32.6	11.1	15.2	-19.8	87.3	122.2	-2.9	-881.6	386.4	71.6	-2.4
BATCH 12 Averages:		*0.211*	*5.5*	*3.7*	*-1.0*	*-31.6*	*8.2*	*15.3*	*-10.3*	*66.4*	*160.3*	*-1.1*	*-768.3*	*294.2*	*21.5*	*9.6*
167	07-Aug-99															
168	08-Aug-99	0.220	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-6.5	3.2	-4.5	-315.3	316.6	0.0	6.1
169	09-Aug-99	0.220	-2.6	3.8	0.1	-9.4	-26.8	32.3	0.9	4.5	76.4	-2.7	-825.0	318.1	71.2	254.0
170	10-Aug-99	0.220	0.0	5.5	0.2	-12.7	-47.1	49.4	-1.8	71.1	158.1	0.6	-1218.5	590.0	-4.1	152.3
171	11-Aug-99	0.220	-0.9	6.6	0.4	-4.6	-38.6	34.2	-5.4	88.2	139.8	-1.3	-884.5	444.0	-163.5	128.3
172	12-Aug-99															
173	13-Aug-99	0.220	0.0	-7.4	6.4	5.9	-40.1	32.3	-9.9	8.1	273.5	19.4	-953.7	526.8	-312.9	108.2
174	14-Aug-99															
175	15-Aug-99	0.220	-1.0	4.0	0.3	0.5	-23.3	15.6	0.0	156.5	189.2	-12.2	-712.5	337.6	-99.8	-204.4
176	16-Aug-99	0.220	4.9	2.0	0.5	-3.1	-19.9	15.6	-7.4	43.1	225.5	-0.3	-1004.2	386.5	3.1	65.2
177	17-Aug-99	0.220	0.5	1.9	0.2	-2.8	-14.0	7.8	2.8	118.8	215.1	-1.6	-1038.5	315.7	-7.8	50.6
178	18-Aug-99	0.220	-1.9	5.8	0.2	-2.8	-19.6	15.6	-1.8	121.2	211.9	-4.2	-1022.3	398.3	-81.1	33.0
179	19-Aug-99	0.220	-3.4	5.6	0.2	-2.6	-12.0	3.9	4.6	85.3	230.6	-0.7	-1154.4	580.1	-83.4	17.6
180	20-Aug-99	0.220	-8.8	9.0	1.2	-4.7	-31.7	23.4	9.2	101.2	200.2	0.7	-886.7	476.2	-163.7	-38.1
181	21-Aug-99															
182	22-Aug-99	0.220	-7.3	21.4	0.9	-4.7	-68.4	58.1	-14.7	118.4	210.6	0.5	-892.4	219.2	39.2	-33.7
183	23-Aug-99	0.220	-22.3	26.5	0.7	-16.2	-70.0	65.9	11.0	112.6	200.4	1.6	-822.7	262.5	-38.1	-37.4
184	24-Aug-99	0.220	-14.0	19.7	1.1	-2.9	-67.2	52.3	3.7	78.9	187.1	-1.5	-870.1	369.2	-75.5	35.9
185	25-Aug-99	0.220	-7.3	10.8	0.9	-3.1	-52.7	50.4	-3.7	83.7	201.3	0.7	-1080.6	474.5	5.2	19.1
186	26-Aug-99	0.220	-4.8	6.6	0.6	-2.9	-43.9	42.8	-0.9	120.6	169.6	2.4	-1090.3	362.7	119.5	14.1
BATCH 13 Averages:		*0.220*	*-4.3*	*7.6*	*1.0*	*-4.3*	*-35.8*	*31.2*	*-0.8*	*81.8*	*180.8*	*-0.2*	*-923.2*	*398.8*	*-49.5*	*35.7*
187	27-Aug-99															
188	28-Aug-99															
189	29-Aug-99	0.250	-1.0	1.7	0.0	1.0	-15.2	3.8	7.3	190.3	71.5	-16.5	-531.6	186.7	-113.8	-56.6
190	30-Aug-99	0.250	-2.9	5.1	-0.6	-18.7	-10.4	19.2	4.6	48.7	136.9	-3.4	-430.7	43.9	78.5	-82.6
191	31-Aug-99	0.250	-5.3	7.7	0.0	0.8	-30.6	23.1	0.9	87.7	66.8	-2.1	-617.1	370.0	-139.1	68.7
192	01-Sep-99	0.250	0.0	8.7	-0.1	-7.6	-41.5	38.5	-7.3	146.5	42.5	-1.7	-583.4	341.7	-38.5	-97.1
193	02-Sep-99	0.250	-3.4	6.3	-0.2	-15.5	-21.4	30.8	-0.9	3.4	121.9	0.2	-532.2	242.4	18.1	12.5
194	03-Sep-99	0.250	-1.4	4.0	-0.2	0.8	-28.7	23.1	-0.9	19.8	129.7	2.0	-603.0	162.5	50.2	76.3
195	04-Sep-99															
196	05-Sep-99	0.250	12.6	1.4	0.2	-2.2	-24.5	-13.6	10.1	114.0	-0.4	2.9	-625.3	441.2	-91.4	36.8
197	06-Sep-99	0.250	3.4	7.5	1.5	-4.9	-45.2	31.0	-5.5	-0.3	137.0	-10.8	-669.9	473.7	-179.2	99.4
198	07-Sep-99	0.250	1.5	3.1	0.4	-3.9	-29.6	19.4	2.6	68.0	86.4	-1.3	-830.0	521.8	-50.2	41.2
199	08-Sep-99	0.250	-0.5	5.2	0.1	-2.5	-33.3	19.4	5.5	53.0	134.6	3.9	-747.4	333.7	-25.5	47.3
200	09-Sep-99	0.250	5.3	1.8	0.2	-2.2	-23.6	11.6	-1.8	87.3	140.2	4.7	-736.9	177.3	87.2	1.8
201	10-Sep-99	0.250	1.0	3.8	0.1	-5.9	-14.4	5.8	3.7	79.3	148.3	2.4	-754.2	331.9	-67.6	25.7
202	11-Sep-99															
203	12-Sep-99															
BATCH 14 Averages:		*0.250*	*0.8*	*4.7*	*0.1*	*-5.1*	*-26.5*	*17.7*	*1.5*	*74.8*	*101.1*	*-1.6*	*-638.5*	*302.2*	*-39.3*	*16.1*
204	13-Sep-99															
205	14-Sep-99															
206	15-Sep-99															
207	16-Sep-99	0.250	3.9	17.5	0.4	-14.0	-17.4	-13.5	0.0	-59.5	244.8	-8.2	-463.7	104.6	-152.3	132.9
208	17-Sep-99															
209	18-Sep-99															
210	19-Sep-99	0.250	-1.0	5.8	0.0	-4.2	-19.9	7.7	5.5	45.0	199.9	-1.0	-843.3	295.0	-12.9	60.9
211	20-Sep-99	0.250	2.9	2.9	0.4	0.5	-17.3	5.8	-1.8	42.4	205.3	0.1	-872.1	307.1	30.5	28.9
212	21-Sep-99	0.250	2.9	3.1	0.4	0.3	-9.6	0.0	-3.7	77.4	191.7	-0.4	-816.6	317.7	-10.4	-35.7
213	22-Sep-99	0.250	2.9	2.2	-0.1	-2.7	-3.3	-3.9	-0.9	111.1	151.1	0.6	-752.9	283.8	-58.3	-4.0
214	23-Sep-99															
215	24-Sep-99															
216	25-Sep-99															
BATCH 15 Averages:		*0.250*	*2.3*	*6.3*	*0.2*	*-4.0*	*-13.5*	*-0.8*	*-0.2*	*43.3*	*198.6*	*-1.8*	*-749.7*	*261.7*	*-40.7*	*36.6*
217	26-Sep-99															
218	27-Sep-99															
219	28-Sep-99	0.320	0.0	3.8	0.0	-2.3	-23.6	12.6	4.0	145.7	24.1	-1.0	-713.6	479.9	-71.4	-38.9
220	29-Sep-99	0.320	19.0	-0.3	-0.9	-3.4	-32.2	12.6	-14.0	114.5	-1.9	-2.5	-725.3	615.9	-95.9	-20.9
221	30-Sep-99	0.320	10.0	0.9	-2.3	-1.1	-14.9	4.2	-8.0	62.2	-3.4	-0.9	-765.7	760.4	-107.1	-8.3
222	01-Oct-99	0.320	3.2	0.4	-0.6	-2.5	-13.1	8.4	0.0	18.1	-1.6	-1.6	-650.3	594.1	16.1	4.7
223	02-Oct-99															
224	03-Oct-99	0.320	3.2	1.1	0.4	-3.0	-78.5	59.0	12.0	63.0	-0.8	-0.7	-706.8	584.6	-127.5	118.3
225	04-Oct-99	0.320	1.5	8.2	-1.4	2.2	-59.9	49.5	-6.6	70.0	2.2	0.7	-778.6	614.1	54.5	-42.8
226	05-Oct-99	0.320	-0.5	13.9	-1.9	2.7	-106.3	71.2	5.6	107.6	28.3	-4.0	-880.4	604.5	-201.2	3.6
227	06-Oct-99	0.320	11.1	4.4	-3.2	-0.0	-96.0	81.3	5.6	123.6	6.6	-6.9	-742.1	474.7	-2.8	12.9
228	07-Oct-99	0.320	-1.5	13.2	-1.0	-1.5	-85.4	51.4	11.3	89.2	4.4	-5.2	-764.3	524.5	-12.4	62.8
229	08-Oct-99	0.320	-2.0	14.7	-0.6	-3.2	-85.7	39.6	21.6	67.0	27.6	-9.5	-736.7	471.3	-0.6	77.2
230	09-Oct-99															
231	10-Oct-99															
BATCH 16 Averages:		*0.320*	*4.4*	*5.8*	*-1.1*	*-1.2*	*-59.6*	*37.0*	*3.2*	*86.1*	*8.6*	*-3.1*	*-726.6*	*572.4*	*-54.8*	*16.9*
232	11-Oct-99															
233	12-Oct-99															
234	13-Oct-99	0.320	6.4	-0.8	-0.8	-0.3	-95.1	77.4	6.3	71.7	-1.0	-1.9	-475.8	377.1	-68.4	23.4
235	14-Oct-99	0.320	4.1	-0.6	0.0	-1.1	-80.9	66.3	7.3	53.9	-1.2	0.7	-509.6	470.0	-128.8	56.2
236	15-Oct-99	0.320	-9.4	13.9	-0.4	0.3	-92.8	61.9	19.9	90.8	5.0	-0.5	-583.4	376.7	-39.6	47.9
237	16-Oct-99															
238	17-Oct-99	0.320	6.1	-0.6	-1.1	0.9	-81.6	55.3	13.6	67.6	0.3	-0.7	-427.5	375.2	-82.0	-3.0
239	18-Oct-99															
240	19-Oct-99	0.320	5.0	1.4	0.2	-0.9	-68.7	46.4	8.4	103.2	-1.9	-0.2	-600.4	558.9	-126.7	-36.0
241	20-Oct-99	0.320	10.0	2.2	-1.8	-1.3	-80.0	50.9	6.3	67.4	0.4	-1.8	-170.9	179.8	-183.6	35.7
242	21-Oct-99	0.320	-13.3	20.8	0.3	-2.4	-120.0	99.6	5.3	33.4	32.6	1.7	-395.3	191.0	41.0	23.4

		EN Sludge	NITRITE							NITRATE						
Day No.	Date	Bypass l/d infl.	Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ SETB+Nit mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ Fin. SET mgN/d	Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ SETB+Nit mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ Fin. SET mgN/d
243	22-Oct-99	0.320	-11.6	26.6	0.8	-0.7	-129.6	68.6	27.3	56.3	53.3	1.0	-557.9	378.9	-112.8	64.3
244	23-Oct-99															
245	24-Oct-99	0.320	-13.3	28.4	0.9	-0.9	-159.6	106.3	20.0	82.1	32.5	-1.1	-568.8	436.9	-106.3	6.7
BATCH 17 Averages:		***0.320***	***-1.8***	***10.2***	***-0.2***	***-0.7***	***-100.9***	***70.3***	***12.7***	***69.6***	***13.4***	***-0.3***	***-476.6***	***371.6***	***-89.7***	***24.3***
246	25-Oct-99															
247	26-Oct-99															
248	27-Oct-99															
249	28-Oct-99	0.320	1.1	0.4	-0.7	-2.8	-0.5	0.0	0.0	6.9	6.0	-5.4	-519.3	560.2	-56.3	-7.6
250	29-Oct-99	0.320	1.1	0.1	-0.6	-0.6	-59.9	57.6	0.0	46.1	-1.1	-0.7	-450.8	436.1	-17.4	-57.3
251	30-Oct-99															
252	31-Oct-99	0.320	2.6	-1.1	0.1	-3.9	-33.9	-4.1	35.4	46.6	-2.7	-3.5	-306.0	341.8	-87.6	-35.4
253	01-Nov-99	0.320	4.7	-0.5	-0.6	-3.8	-48.4	37.3	5.9	28.5	-1.6	-2.0	-388.7	442.3	-145.0	33.9
254	02-Nov-99	0.320	9.9	-0.9	-0.2	-2.2	-5.6	6.2	-16.7	12.4	-6.2	-0.2	-444.1	481.0	-74.0	16.7
255	03-Nov-99	0.320	1.3	0.3	-1.7	-13.1	9.9	2.1	-1.0	18.8	-1.1	-5.1	-426.4	464.8	-57.9	-14.2
256	04-Nov-99	0.320	0.1	0.5	-1.0	-11.0	-22.8	26.9	5.9	4.7	-4.3	1.0	-540.2	548.0	-34.9	18.7
257	05-Nov-99															
258	06-Nov-99															
259	07-Nov-99	0.320	1.0	0.0	-2.1	-4.4	-54.7	37.3	19.7	7.9	-0.4	-1.1	-388.0	418.7	-81.2	31.5
BATCH 18 Averages:		***0.320***	***2.7***	***-0.2***	***-0.8***	***-5.2***	***-27.0***	***20.4***	***6.2***	***21.5***	***-1.4***	***-2.1***	***-432.9***	***481.6***	***-69.3***	***-1.7***
260	08-Nov-99															
261	09-Nov-99															
262	10-Nov-99															
263	11-Nov-99	0.320	2.1	15.2	0.6	-16.7	-71.7	41.5	9.9	95.5	17.6	-3.9	-637.8	353.4	15.4	40.3
264	12-Nov-99	0.320	3.9	24.8	-2.2	-24.9	-79.5	45.7	2.0	100.2	38.5	-5.5	-636.7	384.2	-5.0	-17.4
265	13-Nov-99															
266	14-Nov-99	0.320	3.9	12.3	0.3	-0.8	-50.0	12.5	3.9	69.8	68.3	-3.2	-712.6	407.8	-32.8	57.6
267	15-Nov-99	0.320	-5.2	16.2	0.9	-14.4	-1.7	-41.5	31.6	67.7	42.0	1.1	-607.5	346.5	37.5	-2.6
268	16-Nov-99															
269	17-Nov-99	0.320	7.2	5.6	0.2	-2.9	-26.2	0.0	2.0	125.9	65.8	-1.2	-652.2	472.0	-118.7	-83.9
270	18-Nov-99	0.320	3.7	6.0	0.1	-2.0	-35.6	8.5	8.1	70.9	86.7	-0.9	-680.0	309.7	22.1	28.3
271	19-Nov-99	0.320	3.7	4.5	0.0	-2.9	-21.9	4.3	3.0	107.8	86.6	0.8	-761.4	439.2	-23.4	-46.7
BATCH 19 Averages:		***0.320***	***2.8***	***12.1***	***0.0***	***-9.2***	***-40.9***	***10.1***	***8.6***	***91.1***	***57.9***	***-1.8***	***-669.8***	***387.6***	***-15.0***	***-3.5***
272	20-Nov-99															
273	21-Nov-99	0.320	3.2	-0.2	-1.8	0.4	0.1	-6.4	1.0	36.1	-3.2	-0.9	-628.9	680.6	-85.5	-31.9
274	22-Nov-99	0.320	2.7	-0.1	-0.9	-0.5	-38.5	29.9	4.1	15.0	-1.1	-0.7	-563.7	580.1	-45.2	-0.4
275	23-Nov-99	0.320	1.0	-0.7	0.0	-0.9	-20.8	18.0	1.9	4.0	-2.3	-1.7	-414.7	410.2	-1.9	1.6
276	24-Nov-99	0.320	0.4	-0.2	-1.4	-0.2	1.8	-1.5	0.3	2.6	-2.0	-1.9	-479.0	483.2	-2.0	-4.0
277	25-Nov-99	0.320	0.3	-0.2	-1.9	-0.5	-1.0	0.4	2.1	1.7	-1.1	-2.4	-605.5	617.0	-17.8	5.3
278	26-Nov-99															
279	27-Nov-99															
280	28-Nov-99	0.320	1.1	-0.6	-0.1	-0.8	-5.2	-2.8	6.5	4.1	-2.4	-1.4	-518.9	527.1	-21.5	7.9
281	29-Nov-99															
282	30-Nov-99	0.320	1.2	-0.3	-1.5	-1.6	9.0	-12.1	3.5	4.1	-1.6	-4.5	-357.3	375.5	-25.8	4.4
283	01-Dec-99	0.320	1.3	-0.5	-1.3	-0.0	7.1	-11.7	3.3	5.2	-2.2	-1.7	-423.8	438.4	-23.3	1.8
284	02-Dec-99	0.320	0.8	-0.3	-1.0	-2.3	9.2	-12.3	4.5	5.2	-2.0	-1.2	-419.0	434.9	-26.9	3.4
BATCH 20 Averages:		***0.320***	***1.3***	***-0.4***	***-1.1***	***-0.7***	***-4.3***	***0.2***	***3.0***	***8.7***	***-2.0***	***-1.8***	***-490.1***	***505.2***	***-27.8***	***-1.3***
285	03-Dec-99															
286	04-Dec-99															
287	05-Dec-99	0.320	1.0	-0.2	-0.6	-0.8	5.2	-9.9	3.9	4.2	-1.9	-1.7	-477.9	491.6	-23.3	4.4
288	06-Dec-99	0.320	1.6	-0.3	-1.0	-1.4	-8.7	-0.9	8.2	4.2	-2.1	-0.7	-402.4	414.4	-29.4	11.0
289	07-Dec-99	0.320	2.0	-0.3	-1.2	-1.9	5.5	-5.8	-0.7	9.1	-1.7	-3.2	-377.3	399.1	-36.2	-0.0
290	08-Dec-99	0.320	0.4	0.0	-1.0	-0.6	0.9	-2.7	2.2	10.2	-1.5	-2.4	-425.5	428.2	-30.4	9.6
291	09-Dec-99	0.320	0.6	-0.3	-1.2	-0.2	0.4	-3.3	2.9	9.0	-2.7	-1.7	-494.0	495.3	-27.3	11.2
292	10-Dec-99															
293	11-Dec-99															
294	12-Dec-99	0.320	0.8	-0.7	0.2	-4.5	4.1	-2.3	1.2	7.1	-1.8	-1.7	-426.6	428.5	-18.2	4.2
295	13-Dec-99	0.320	0.5	-0.3	-0.3	-15.1	14.7	-0.5	0.0	11.2	-1.8	-4.2	-393.9	395.3	-31.0	11.6
296	14-Dec-99															
BATCH 21 Averages:		***0.320***	***1.0***	***-0.3***	***-0.8***	***-3.5***	***3.2***	***-3.6***	***2.5***	***7.9***	***-1.9***	***-2.2***	***-428.2***	***436.0***	***-28.0***	***7.4***
297	15-Dec-99															
298	16-Dec-99															
299	17-Dec-99	0.320	0.8	0.1	-0.3	-10.1	-22.2	25.6	4.6	22.6	-2.7	-8.2	-588.5	584.5	-46.0	13.8
300	18-Dec-99															
301	19-Dec-99	0.320	44.5	2.3	2.1	-3.0	-155.7	45.3	14.2	62.4	-2.1	-0.1	-663.7	582.9	-63.7	18.7
302	20-Dec-99	0.320	33.1	23.0	1.2	-1.1	-151.1	51.7	-14.2	75.9	2.8	-2.0	-712.2	634.6	-59.9	-20.7
303	21-Dec-99	0.320	28.8	0.2	-0.2	-2.7	-107.1	65.0	-13.2	62.9	-1.6	-0.6	-747.5	697.6	-79.3	3.5
304	22-Dec-99	0.320	15.5	0.4	-0.6	-0.4	-113.7	64.1	16.9	64.9	0.9	-4.0	-540.1	472.3	-97.1	32.2
305	23-Dec-99	0.320	13.5	2.1	0.5	-2.9	-101.3	67.3	3.6	83.0	-1.0	-3.0	-566.2	489.6	-105.8	16.3
306	24-Dec-99															
307	25-Dec-99															
308	26-Dec-99	0.320	-1.0	14.5	0.9	-1.3	-109.1	80.3	0.5	77.7	15.6	-9.0	-593.0	477.2	-69.3	3.7
309	27-Dec-99	0.320	2.3	1.2	-1.3	-3.6	-93.9	78.1	12.3	69.0	-1.8	-2.0	-635.8	552.3	-69.3	15.9
310	28-Dec-99	0.320	1.0	-0.3	0.4	-2.7	-74.9	62.5	11.3	55.7	-2.8	-1.1	-601.1	542.2	-58.1	7.5
311	29-Dec-99	0.320	1.3	0.0	-1.1	-3.6	-71.8	63.6	8.7	44.6	-0.7	-3.3	-608.5	525.5	-43.8	38.3
BATCH 22 Averages:		***0.320***	***14.0***	***4.4***	***0.2***	***-3.1***	***-100.1***	***60.4***	***4.5***	***61.9***	***0.7***	***-3.3***	***-625.7***	***555.9***	***-69.2***	***12.9***
312	30-Dec-99															
313	31-Dec-99															
314	01-Jan-00															
315	02-Jan-00	0.320	-1.1	22.8	0.5	-8.2	-36.3	-20.2	16.2	98.4	218.9	-0.3	-1026.0	516.8	-99.3	-33.0
316	03-Jan-00	0.320	3.2	17.9	0.4	-4.7	-24.3	-25.6	10.1	93.1	216.2	1.1	-1122.7	661.5	-144.8	-20.6
317	04-Jan-00	0.320	4.3	6.9	0.0	-6.3	-22.5	5.3	0.0	225.9	18.1	-6.2	-813.4	724.9	-153.6	-231.2
318	05-Jan-00	0.320	0.5	3.2	-1.3	-1.6	-45.0	24.5	14.2	83.6	4.3	-2.3	-873.5	814.4	-137.3	19.5
319	06-Jan-00	0.320	-3.2	6.4	-0.2	-4.2	-56.2	31.9	16.2	77.3	11.5	-1.8	-797.1	704.6	-120.5	32.2
320	07-Jan-00	0.320	-3.7	11.0	0.6	-6.6	-24.7	4.3	10.1	40.2	76.0	-2.0	-828.3	620.2	-108.3	78.2
321	08-Jan-00															
322	09-Jan-00															

Day No.	Date	EN Sludge Bypass l/d infl.	NITRITE							NITRATE						
			Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ SETB+Nit mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ Fin. SET mgN/d	Δ PreANO mgN/d	Δ AN mgN/d	Δ SETA mgN/d	Δ SETB+Nit mgN/d	Δ ANO mgN/d	Δ AE mgN/d	Δ Fin. SET mgN/d
323	10-Jan-00	0.320	2.7	0.4	-1.5	-20.0	-21.1	28.1	7.2	45.1	1.8	-2.5	-503.0	485.9	-63.6	-13.5
324	11-Jan-00	0.320	0.5	4.1	-1.1	-16.2	-42.0	34.6	13.3	53.9	4.1	1.1	-557.3	501.6	-81.2	14.1
325	12-Jan-00	0.320	-4.9	14.5	-0.9	-3.3	-81.1	24.9	16.5	31.5	33.1	-0.2	-603.2	438.9	-29.3	57.5
326	13-Jan-00	0.320	-9.7	23.7	0.9	-4.3	-76.4	17.3	30.8	50.8	70.8	-2.6	-653.1	429.0	-28.4	7.2
327	14-Jan-00	0.320	3.8	0.4	-0.6	-3.4	-83.9	70.2	7.2	80.7	3.8	-2.0	-684.8	646.1	-79.1	-49.4
BATCH 23 Averages:		***0.320***	***-0.7***	***10.3***	***-0.3***	***-7.0***	***-44.9***	***17.8***	***13.1***	***60.0***	***59.9***	***-1.6***	***-769.3***	***594.9***	***-95.0***	***-12.7***
328	15-Jan-00															
329	16-Jan-00	0.320	0.8	1.1	0.0	-0.9	-51.9	40.4	7.2	43.1	3.3	-2.6	-421.5	340.6	-49.2	34.6
330	17-Jan-00	0.320	-3.0	5.4	0.1	-1.3	-38.0	25.9	7.2	54.1	14.0	-2.7	-440.7	340.6	-55.5	18.9
331	18-Jan-00	0.320	-11.0	17.9	0.2	-0.7	-68.6	19.9	32.2	8.3	85.3	-2.0	-753.2	490.8	-49.6	116.0
332	19-Jan-00	0.320	5.9	-0.6	-1.2	0.2	-38.8	23.2	4.6	54.0	1.2	-4.5	-752.2	731.7	-136.3	45.5
333	20-Jan-00	0.320	-5.1	12.9	0.9	-0.0	-89.4	51.2	17.9	40.3	32.6	-0.9	-549.7	397.9	-64.4	63.5
334	21-Jan-00	0.320	-8.5	20.3	1.3	-0.9	-76.7	39.3	6.7	26.2	76.4	-0.4	-681.0	516.0	-105.3	58.1
335	22-Jan-00															
336	23-Jan-00															
337	24-Jan-00	0.320	16.6	15.5	1.0	1.1	-112.5	75.1	-29.6	160.8	61.1	-2.4	-590.4	282.7	-31.2	-138.8
338	25-Jan-00	0.320	-4.8	13.4	1.7	1.3	-111.4	79.4	8.2	98.3	40.2	-0.3	-737.7	441.4	-14.5	26.9
339	26-Jan-00	0.320	-3.8	13.0	-0.6	1.8	-96.2	78.3	-3.1	96.3	55.9	1.3	-939.9	514.2	56.8	54.7
340	27-Jan-00															
341	28-Jan-00															
BATCH 24 Averages:		***0.320***	***-1.2***	***11.0***	***0.4***	***0.1***	***-75.9***	***48.1***	***5.7***	***66.8***	***41.1***	***-1.6***	***-651.6***	***450.7***	***-49.9***	***31.0***
342	29-Jan-00															
343	30-Jan-00															
344	31-Jan-00	0.320	0.5	0.4	-0.4	0.9	-3.0	-7.0	6.6	35.9	-1.7	-1.0	-436.8	439.5	-52.7	-18.3
345	01-Feb-00	0.320	0.8	-0.7	0.5	0.8	-2.0	-1.1	0.0	26.8	-2.6	0.2	-597.6	597.3	-55.1	4.2
346	02-Feb-00															
347	03-Feb-00	0.320	0.5	-0.1	-4.5	4.5	-1.3	-0.5	0.0	14.4	-2.0	-3.2	-658.6	661.1	-20.5	-5.6
348	04-Feb-00	0.320	0.6	0.1	-0.2	0.6	-1.0	-1.2	0.0	9.0	-1.8	-2.7	-220.8	220.3	-2.3	-10.7
349	05-Feb-00															
350	06-Feb-00	0.320	0.6	0.3	-0.2	0.6	-2.2	0.0	-0.5	11.4	-1.2	-2.7	-230.1	230.0	-32.0	12.0
351	07-Feb-00	0.320	0.6	-0.1	0.0	0.6	-2.2	0.0	0.0	16.5	-1.1	-2.2	-245.2	244.4	-36.3	6.6
352	08-Feb-00	0.320	1.0	-0.5	0.2	0.6	-1.0	-1.2	-0.5	12.0	-1.3	-2.1	-284.5	279.0	-10.1	-5.2
353	09-Feb-00	0.320	0.6	-0.2	0.0	0.6	-1.0	-1.2	0.0	8.3	-1.0	-2.6	-339.4	334.3	-15.3	6.6
354	10-Feb-00	0.320	1.1	-0.3	-0.2	0.8	-1.0	-1.2	-0.5	8.6	-1.0	-2.0	-351.6	342.4	-14.4	8.8
355	11-Feb-00															
BATCH 25 Averages:		***0.320***	***0.7***	***-0.1***	***-0.5***	***1.1***	***-1.6***	***-1.5***	***0.6***	***15.9***	***-1.5***	***-2.0***	***-373.9***	***372.0***	***-26.5***	***-0.2***
356	12-Feb-00															
357	13-Feb-00															
358	14-Feb-00	0.320	1.1	-0.1	-0.2	0.8	-1.6	-1.1	-0.5	36.3	0.1	-2.2	-476.6	477.8	-63.6	-11.0
359	15-Feb-00	0.320	0.6	0.2	-0.5	-1.0	-18.6	17.2	0.5	33.8	-0.6	-3.8	-692.3	690.2	-96.2	30.2
360	16-Feb-00	0.320	0.9	0.0	-0.5	-8.8	6.4	0.0	0.5	41.1	-2.6	-2.6	-607.1	612.2	-73.9	-9.2
361	17-Feb-00	0.320	1.1	-0.1	-0.8	-0.7	-1.3	0.0	0.0	33.3	-1.5	-5.3	-802.3	807.9	-66.8	0.0
362	18-Feb-00															
363	19-Feb-00															
364	20-Feb-00	0.320	0.6	0.0	-1.5	-1.2	0.9	-0.6	0.5	33.3	-0.5	-4.0	-726.3	732.0	-87.5	16.8
365	21-Feb-00	0.320	1.7	-1.8	1.1	-2.7	2.9	-0.4	-3.4	12.9	-2.9	-0.1	-426.4	429.0	-34.3	8.2
366	22-Feb-00	0.320	0.8	-1.5	-1.7	-23.6	25.8	-1.0	0.0	15.8	-0.9	-1.9	-551.0	553.2	-30.4	-1.2
367	23-Feb-00	0.320	-0.6	1.3	-1.5	-4.5	5.4	-3.3	1.9	14.1	-0.6	-2.0	-547.6	550.1	-26.8	-1.7
368	24-Feb-00	0.320	4.2	-4.6	3.9	-0.8	-5.5	4.6	-6.4	10.9	-1.1	-0.7	-556.8	558.1	-29.3	7.6
BATCH 26 Averages:		***0.320***	***1.2***	***-0.7***	***-0.2***	***-4.7***	***1.6***	***1.7***	***-0.8***	***25.7***	***-1.2***	***-2.6***	***-598.5***	***601.2***	***-56.6***	***4.4***
369	25-Feb-00															
370	26-Feb-00															
371	27-Feb-00	0.320	0.9	-2.8	1.8	-22.9	22.6	-1.7	0.1	13.0	-2.2	1.5	-287.4	288.4	-24.2	-2.4
372	28-Feb-00	0.320	1.8	-0.4	-0.5	-11.1	1.3	9.3	-2.8	13.2	-0.5	-2.1	-614.1	614.6	-20.9	-3.4
373	29-Feb-00	0.320	2.4	-2.9	1.8	-8.7	-16.5	21.0	0.2	10.3	-1.3	-6.1	-548.4	551.1	-25.0	8.2
374	01-Mar-00	0.320	1.2	-0.6	-0.2	-4.0	-10.9	12.7	0.2	9.9	-0.2	-10.9	-569.6	575.2	-26.4	7.4
375	02-Mar-00	0.320	0.5	0.3	-1.3	-5.8	-1.5	7.7	-1.8	8.8	-2.1	-7.7	-616.9	623.5	-23.4	7.8
376	03-Mar-00															
377	04-Mar-00															
378	05-Mar-00	0.320	2.5	-1.9	1.3	-7.8	1.3	5.3	-3.7	10.1	-3.4	-2.3	-631.0	635.7	-21.8	2.3
379	06-Mar-00	0.320	0.6	-0.3	-0.3	-4.6	-6.6	10.1	-0.1	13.3	-1.0	-5.7	-566.0	572.7	-31.4	5.9
380	07-Mar-00	0.320	1.1	-0.3	-0.3	-1.3	-45.4	46.0	-1.2	15.1	-1.6	-3.0	-615.7	614.4	-36.9	12.2
381	08-Mar-00															
382	09-Mar-00															
BATCH 27 Averages:		***0.320***	***1.4***	***-1.1***	***0.3***	***-8.3***	***-7.0***	***13.8***	***-1.1***	***11.7***	***-1.6***	***-4.5***	***-556.4***	***559.5***	***-26.3***	***4.7***
383	10-Mar-00															
384	11-Mar-00															
385	12-Mar-00	0.310	21.1	15.8	1.3	-1.5	-119.1	38.3	4.9	44.5	17.8	-20.5	-1015.1	998.3	-93.2	4.2
386	13-Mar-00	0.310	11.8	3.2	0.1	-1.5	-83.4	48.0	5.4	55.7	-0.0	-10.6	-873.4	883.3	-132.5	19.4
387	14-Mar-00	0.310	-2.9	15.0	5.4	-8.0	-92.2	53.0	10.9	52.4	6.2	-3.2	-780.3	776.3	-128.5	15.1
388	15-Mar-00	0.310	35.5	-1.3	1.0	-10.0	-105.4	21.7	21.2	55.3	-2.7	-2.5	-928.5	926.6	-30.9	-68.3
389	16-Mar-00	0.310	46.6	3.2	1.3	-3.2	-115.0	53.0	-36.4	58.2	-2.9	-1.6	-919.3	904.9	24.0	-115.7
390	17-Mar-00															
391	18-Mar-00															
392	19-Mar-00	0.310	1.9	22.4	0.0	-3.2	-102.2	65.8	-9.7	66.7	28.6	-2.7	-899.5	836.3	-121.5	-4.0
393	20-Mar-00	0.310	-2.5	1.9	11.3	0.8	-50.7	21.5	5.9	57.2	43.0	1.8	-878.7	731.4	-110.3	39.5
394	21-Mar-00	0.310	-0.3	10.5	0.5	0.8	-32.6	6.2	3.2	83.1	68.9	-7.8	-1011.7	820.4	-130.0	20.3
395	22-Mar-00	0.310	0.6	4.4	-1.0	1.9	-20.6	7.3	1.1	105.3	45.1	-12.5	-932.6	766.7	-137.1	10.3
396	23-Mar-00															
397	24-Mar-00															
BATCH 28 Averages:		***0.310***	***12.4***	***8.3***	***2.2***	***-2.7***	***-80.1***	***35.0***	***0.7***	***64.3***	***22.7***	***-6.6***	***-915.4***	***849.4***	***-95.5***	***-6.6***
398	25-Mar-00															
399	26-Mar-00	0.310	0.6	0.2	-0.2	1.0	-3.2	0.0	0.0	42.5	0.5	-3.0	-727.4	725.4	-68.3	-15.4
400	27-Mar-00	0.310	11.2	-0.5	0.1	0.5	-1.3	-3.6	-16.9	22.4	-3.4	-1.1	-523.8	527.1	-53.0	7.6
401	28-Mar-00	0.310	1.1	-0.1	-0.1	0.7	-1.0	-4.6	2.2	22.0	-0.8	-2.1	-533.4	535.8	-85.6	39.4
402	29-Mar-00	0.310	0.0	1.0	-1.6	1.9	-4.5	1.1	0.2	21.5	-1.2	-2.1	-589.3	592.9	-50.9	5.8

		EN Sludge	NITRITE							NITRATE						
		Bypass	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET
Day No.	Date	l/d infl.	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d
403	30-Mar-00	0.310	1.1	0.3	-0.9	1.0	-0.9	-4.2	1.7	20.0	-2.0	-1.5	-597.6	601.0	-47.8	6.7
404	31-Mar-00															
405	01-Apr-00															
406	02-Apr-00	0.310	0.1	0.6	-0.5	0.9	-12.3	-7.0	16.1	14.9	-1.5	0.5	-626.4	624.2	-35.3	7.2
407	03-Apr-00	0.310	0.7	0.0	-0.2	-3.1	2.9	-2.3	0.5	12.4	-2.1	-3.6	-510.7	515.2	-43.4	10.1
BATCH 29 Averages:		***0.310***	***2.1***	***0.2***	***-0.5***	***0.4***	***-2.9***	***-3.0***	***0.6***	***22.3***	***-1.5***	***-1.8***	***-586.9***	***588.8***	***-54.9***	***8.8***
408	04-Apr-00															
409	05-Apr-00															
410	06-Apr-00	0.310	1.7	0.9	-3.0	-4.5	3.8	-3.4	1.1	45.6	-2.2	-2.4	-656.5	662.1	-113.7	18.5
411	07-Apr-00															
412	08-Apr-00															
413	09-Apr-00	0.310	3.3	3.4	-0.3	-3.0	-5.7	-5.2	0.0	48.9	-3.6	1.2	-654.4	657.6	-109.4	6.5
414	10-Apr-00	0.310	5.3	-0.1	-0.1	-3.1	-11.5	-1.7	4.9	54.6	-0.7	-1.6	-714.1	701.5	-109.4	12.3
415	11-Apr-00	0.270	2.6	-0.3	-0.2	1.0	-20.6	13.6	0.0	59.2	-1.2	-1.4	-630.0	567.5	-73.8	16.4
416	12-Apr-00	0.270	0.9	-0.1	-0.5	1.2	-19.4	13.8	2.2	53.6	-2.4	-1.5	-712.4	630.7	-57.4	33.2
417	13-Apr-00	0.270	1.3	-0.5	-0.2	1.0	-18.9	14.4	1.1	65.6	-1.4	-3.2	-778.2	692.5	-58.9	16.2
418	14-Apr-00															
419	15-Apr-00															
420	16-Apr-00	0.270	1.2	-0.2	-0.2	0.9	-20.6	16.1	1.1	56.4	-2.3	-1.0	-804.5	719.2	-36.1	11.0
421	17-Apr-00															
BATCH 30 Averages:		***0.29***	***2.4***	***0.4***	***-0.7***	***-0.9***	***-13.3***	***6.8***	***1.5***	***54.9***	***-2.0***	***-1.4***	***-707.2***	***661.6***	***-79.8***	***16.3***
422	18-Apr-00															
423	19-Apr-00															
424	20-Apr-00															
425	21-Apr-00															
426	22-Apr-00															
427	23-Apr-00															
428	24-Apr-00	0.314	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.8	-1.8	-5.5	-679.6	667.3	-27.3	-20.3
429	25-Apr-00	0.314	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	-2.6	-1.9	-716.3	718.6	-27.3	-4.5
430	26-Apr-00	0.314	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	-1.4	-1.9	-719.1	720.5	2.4	-10.1
431	27-Apr-00	0.314	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	-1.9	-2.1	-800.5	805.0	-2.4	0.0
432	28-Apr-00	0.314	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	-1.4	-2.8	-820.3	825.0	-16.6	9.0
433	29-Apr-00															
434	30-Apr-00	0.314	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.9	-1.7	-2.4	-764.7	769.0	-49.8	9.0
435	01-May-00	0.314	-0.1	-0.1	0.0	-3.2	2.9	0.0	0.3	13.8	-2.2	-3.7	-700.2	705.6	-26.6	-0.9
436	02-May-00	0.314	-0.1	-0.4	-0.3	-4.2	0.2	4.3	0.3	15.1	-1.5	-6.9	-734.1	740.2	-30.6	2.4
437	03-May-00	0.314	0.0	-0.4	-0.3	-1.7	-3.3	4.1	1.4	14.3	-0.6	-3.9	-692.7	695.0	-40.6	12.9
438	04-May-00	0.314	-0.1	-0.7	0.0	-1.5	1.2	-0.1	0.7	18.8	-2.1	-2.8	-755.3	759.3	-46.5	9.4
BATCH 31 Averages:		***0.314***	***-0.0***	***-0.2***	***-0.1***	***-1.1***	***0.1***	***0.8***	***0.3***	***14.1***	***-1.7***	***-3.4***	***-738.3***	***740.5***	***-26.5***	***0.7***
439	05-May-00															
440	06-May-00															
441	07-May-00															
442	08-May-00	0.314	4.3	-0.4	0.0	-3.0	0.9	-6.6	0.0	15.3	-2.4	-3.7	-934.3	938.7	-67.8	37.1
443	09-May-00	0.368	8.6	-5.8	-10.7	9.7	-78.1	53.5	12.4	69.7	-2.6	11.6	-724.3	653.2	-109.4	29.7
444	10-May-00	0.368	1.4	-0.9	-3.8	0.2	-15.9	13.0	2.7	58.5	-4.5	-23.5	-838.7	858.9	-108.7	-0.5
445	11-May-00	0.368	0.9	-1.0	0.8	-3.3	-15.2	13.0	2.7	49.7	-3.4	-7.3	-905.3	907.7	-110.9	17.2
446	12-May-00	0.368	0.9	-1.7	-7.7	3.4	3.7	0.0	0.0	52.5	-2.5	3.9	-961.6	955.7	-93.2	-7.7
447	13-May-00															
448	14-May-00	0.368	0.7	-1.6	-0.1	-2.7	3.0	-0.7	0.0	52.3	-1.6	-15.5	-1014.8	1026.9	-123.9	22.1
449	15-May-00	0.368	1.1	-0.9	1.7	-4.2	-48.7	39.0	8.9	63.9	-3.3	-1.7	-977.9	858.2	-104.3	94.0
450	16-May-00															
451	17-May-00	0.368	2.6	-0.7	0.6	0.9	-61.9	54.9	0.0	130.0	0.2	-2.6	-1065.5	954.8	-110.7	-36.6
452	18-May-00	0.368	2.7	-0.5	0.4	0.8	-58.3	44.0	6.9	96.5	-3.6	-2.3	-1013.9	846.2	-106.9	81.8
453	19-May-00															
454	20-May-00															
455	21-May-00	0.368	5.8	-0.4	-0.6	-17.7	-31.4	27.4	10.3	129.5	3.6	-5.9	-1205.7	1132.0	-105.5	-79.7
456	22-May-00															
BATCH 32 Averages:		***0.363***	***2.9***	***-1.4***	***-2.0***	***-1.6***	***-30.2***	***23.8***	***4.4***	***71.8***	***-2.0***	***-4.7***	***-964.2***	***913.2***	***-104.2***	***15.7***
457	23-May-00															
458	24-May-00															
459	25-May-00															
460	26-May-00															
461	27-May-00															
462	28-May-00															
463	29-May-00															
464	30-May-00															
465	31-May-00															
466	01-Jun-00															
467	02-Jun-00															
468	03-Jun-00															
469	04-Jun-00															
470	05-Jun-00															
BATCH 33 Averages:																
471	06-Jun-00															
472	07-Jun-00															
473	08-Jun-00															
474	09-Jun-00															
475	10-Jun-00															
476	11-Jun-00	0.368	-2.2	10.8	0.6	0.7	-11.4	-39.0	26.8	126.6	303.3	8.6	-1249.4	414.1	-79.2	27.9
477	12-Jun-00	0.368	5.8	7.5	0.0	0.9	-11.3	-34.7	16.5	188.6	277.4	-1.9	-1330.9	545.0	-68.0	-75.0
478	13-Jun-00	0.368	7.2	6.1	0.1	0.8	-9.9	-27.5	8.2	216.7	200.8	-4.8	-1366.3	728.4	-53.4	-127.3
479	14-Jun-00	0.368	1.4	9.6	0.9	0.7	-14.3	-34.7	22.0	179.0	205.4	0.7	-1291.8	646.9	-68.0	-58.3
480	15-Jun-00	0.368	-5.8	24.3	0.3	1.2	-17.1	-49.1	24.7	111.5	271.8	2.5	-1531.9	616.5	-19.3	-39.1
481	16-Jun-00	0.368	-1.4	28.3	0.7	1.1	-17.1	-57.6	16.5	125.9	265.3	4.3	-1567.3	779.1	48.5	-34.2
482	17-Jun-00															
483	18-Jun-00	0.368	1.4	34.0	0.1	1.7	-28.5	-59.2	12.4	107.4	318.8	3.0	-1548.3	602.6	-96.3	-19.5

		EN Sludge	NITRITE							NITRATE						
		Bypass	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET	Δ PreANO	Δ AN	Δ SETA	Δ SETB+Nit	Δ ANO	Δ AE	Δ Fin. SET
Day No.	Date	l/d infl.	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d	mgN/d
BATCH 34 Averages:		0.37	0.9	17.3	0.4	1.0	-15.7	-43.1	18.4	150.8	263.3	1.8	-1416.1	676.1	-48.0	-46.5

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
1	22-Feb-99	102.3	384.8	400.9	138.0	-48.3	977.7	1321.6	74.0
2	23-Feb-99	94.9	432.8	303.9	153.7	-102.4	883.0	1274.0	69.3
3	24-Feb-99	130.9	532.1	471.3	265.5	-89.1	1310.7	1064.0	123.2
4	25-Feb-99	147.9	681.3	8.4	118.2	-226.3	729.4	1106.0	66.0
5	26-Feb-99								
6	27-Feb-99								
7	28-Feb-99								
8	01-Mar-99	58.2	828.8	396.6	103.7	-123.3	1264.0	1176.0	107.5
9	02-Mar-99	19.9	734.4	288.2	76.1	30.5	1149.2	1304.8	88.1
10	03-Mar-99								
11	04-Mar-99								
BATCH 1 Averages:		***92.3***	***599.0***	***311.6***	***142.5***	***-93.1***	***1052.3***	***1207.7***	***88.0***
12	05-Mar-99								
13	06-Mar-99								
14	07-Mar-99								
15	08-Mar-99								
BATCH 2 Averages:		***Bad Batch***							
16	09-Mar-99								
17	10-Mar-99								
18	11-Mar-99								
19	12-Mar-99								
20	13-Mar-99								
21	14-Mar-99								
22	15-Mar-99								
23	16-Mar-99								
24	17-Mar-99								
25	18-Mar-99								
BATCH 3 Averages:									
26	19-Mar-99								
27	20-Mar-99								
28	21-Mar-99								
29	22-Mar-99	129.6	672.7	228.3	453.3	28.5	1512.4	1733.2	87.3
30	23-Mar-99	128.6	566.4	174.9	400.2	-279.0	991.0	1663.2	59.6
31	24-Mar-99								
32	25-Mar-99	69.7	824.0	275.3	409.5	-118.8	1459.6	1786.4	81.7
33	26-Mar-99								
34	27-Mar-99								
35	28-Mar-99								
36	29-Mar-99								
37	30-Mar-99								
38	31-Mar-99								
BATCH 4 Averages:		***109.3***	***687.7***	***226.1***	***421.0***	***-123.1***	***1321.0***	***1727.6***	***76.2***
39	01-Apr-99								
40	02-Apr-99								
41	03-Apr-99								
42	04-Apr-99								
43	05-Apr-99	123.3	637.1	282.6	321.6	-10.4	1354.2	1425.2	95.0
44	06-Apr-99								
45	07-Apr-99								
46	08-Apr-99								
47	09-Apr-99								
48	10-Apr-99								
49	11-Apr-99	62.9	389.9	270.5	384.9	83.7	1191.9	1428.0	83.5
50	12-Apr-99	96.5	390.2	254.2	381.7	-34.9	1087.7	1453.2	74.9
51	13-Apr-99	88.1	521.4	232.5	382.0	105.1	1329.1	1447.6	91.8

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
52	14-Apr-99								
53	15-Apr-99	80.8	667.4	250.3	432.3	-102.3	1328.6	1456.0	91.2
54	16-Apr-99								
BATCH 5 Averages:		***90.3***	***521.2***	***258.0***	***380.5***	***8.2***	***1258.3***	***1442.0***	***87.3***
55	17-Apr-99								
56	18-Apr-99								
57	19-Apr-99	71.8	696.1	196.9	153.2	88.8	1206.9	1624.0	74.3
58	20-Apr-99								
59	21-Apr-99								
60	22-Apr-99	151.6	701.7	282.4	275.2	227.1	1637.9	1626.8	100.7
61	23-Apr-99								
62	24-Apr-99								
63	25-Apr-99								
64	26-Apr-99								
65	27-Apr-99	173.4	840.5	235.4	292.5	90.4	1632.2	1618.4	100.9
66	28-Apr-99	243.8	561.6	254.6	223.2	139.5	1422.6	1663.2	85.5
67	29-Apr-99	324.1	1082.3	245.6	260.6	123.7	2036.1	1626.8	125.2
BATCH 6 Averages:		***192.9***	***776.4***	***243.0***	***240.9***	***133.9***	***1587.2***	***1631.8***	***97.3***
68	30-Apr-99								
69	01-May-99								
70	02-May-99								
71	03-May-99	58.2	480.3	250.9	123.1	63.2	975.6	1156.4	84.4
72	04-May-99	218.0	864.1	250.8	201.6	14.6	1549.0	1190.0	130.2
73	05-May-99	170.0	800.6	272.5	193.5	21.7	1458.2	1122.8	129.9
74	06-May-99	141.2	804.8	245.1	151.0	18.8	1361.0	1190.0	114.4
75	07-May-99	123.7	746.8	236.7	162.5	-12.8	1256.9	1075.2	116.9
76	08-May-99								
77	09-May-99	99.3	558.3	252.9	147.6	160.7	1218.8	1100.4	110.8
78	10-May-99	122.5	649.0	236.1	127.3	98.0	1232.8	1139.6	108.2
79	11-May-99	146.1	668.9	249.5	175.1	122.6	1362.2	1212.4	112.4
80	12-May-99	135.9	744.1	233.9	188.3	20.7	1322.9	1212.4	109.1
81	13-May-99	117.0	620.8	252.5	208.1	123.4	1321.9	1218.0	108.5
82	14-May-99								
BATCH 7 Averages:		***133.2***	***693.8***	***248.1***	***167.8***	***63.1***	***1305.9***	***1161.7***	***112.5***
83	15-May-99								
84	16-May-99	70.2	726.3	219.7	296.2	162.5	1474.9	1545.6	95.4
85	17-May-99	134.4	667.5	234.4	415.5	195.4	1647.1	1542.8	106.8
86	18-May-99	196.6	907.6	229.8	328.2	68.1	1730.3	1610.0	107.5
87	19-May-99								
88	20-May-99								
89	21-May-99								
90	22-May-99								
91	23-May-99								
92	24-May-99	125.3	826.8	296.0	364.2	84.3	1696.5	1635.2	103.8
93	25-May-99	114.0	837.4	256.5	320.3	-25.2	1502.9	1542.8	97.4
94	26-May-99	150.9	741.8	207.1	314.8	268.1	1682.6	1556.8	108.1
95	27-May-99	122.3	682.2	222.4	280.4	250.7	1558.2	1584.8	98.3
96	28-May-99								
97	29-May-99								
98	30-May-99								
BATCH 8 Averages:		***130.5***	***769.9***	***238.0***	***331.4***	***143.4***	***1613.2***	***1574.0***	***102.5***
99	31-May-99								
100	01-Jun-99								
101	02-Jun-99								
102	03-Jun-99								

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
BATCH 9 Averages:		***Bad Batch***							
103	04-Jun-99								
104	05-Jun-99								
105	06-Jun-99	0.0	228.1	182.8	304.3	39.9	755.1	1251.6	60.3
106	07-Jun-99	0.0	240.4	201.8	276.4	76.8	795.4	1251.6	63.5
107	08-Jun-99	0.0	348.4	184.0	253.4	95.5	881.2	1276.8	69.0
108	09-Jun-99	0.0	317.0	201.9	245.8	78.3	843.0	1251.6	67.4
109	10-Jun-99								
110	11-Jun-99								
111	12-Jun-99								
112	13-Jun-99								
113	14-Jun-99								
114	15-Jun-99								
115	16-Jun-99	182.4	101.0	207.7	328.7	218.2	1038.0	1307.6	79.4
116	17-Jun-99	273.8	36.3	227.7	301.1	183.3	1022.2	1243.2	82.2
117	18-Jun-99								
118	19-Jun-99								
119	20-Jun-99	379.0	34.7	180.7	158.8	179.5	932.6	1293.6	72.1
120	21-Jun-99	312.4	33.9	202.8	155.7	253.3	958.1	1262.8	75.9
121	22-Jun-99	256.4	39.2	186.8	182.1	349.5	1014.0	1318.8	76.9
122	23-Jun-99	279.5	67.2	152.3	116.0	264.9	879.9	1268.4	69.4
123	24-Jun-99								
124	25-Jun-99								
125	26-Jun-99								
126	27-Jun-99								
127	28-Jun-99	556.5	41.9	169.8	116.3	183.6	1068.1	1240.4	86.1
128	29-Jun-99								
129	30-Jun-99	600.2	145.2	181.7	119.9	-13.7	1033.3	1262.8	81.8
130	01-Jul-99	622.1	95.2	174.3	84.1	6.7	982.5	1260.0	78.0
131	02-Jul-99	590.9	70.9	173.3	107.0	92.0	1034.1	1251.6	82.6
132	03-Jul-99								
133	04-Jul-99								
134	05-Jul-99								
BATCH 10 Averages:		***289.5***	***128.5***	***187.7***	***196.4***	***143.4***	***945.5***	***1267.2***	***74.6***
135	06-Jul-99	873.7	135.2	252.6	192.0	-112.8	1340.8	1937.6	69.2
136	07-Jul-99	877.4	210.9	264.2	389.5	-262.8	1479.2	1800.4	82.2
137	08-Jul-99	878.3	120.3	280.8	361.3	-264.9	1375.7	1761.2	78.1
138	09-Jul-99	923.7	184.7	276.1	400.7	-349.3	1436.0	1702.4	84.4
139	10-Jul-99	865.3	205.2	276.3	370.5	-244.3	1473.0	1668.8	88.3
140	11-Jul-99	806.8	228.7	261.8	332.1	-124.1	1505.3	1738.8	86.6
141	12-Jul-99								
142	13-Jul-99	816.5	533.4	262.7	342.3	-390.8	1564.1	1643.6	95.2
143	14-Jul-99	822.3	447.9	285.9	362.4	-220.6	1697.9	1864.8	91.0
144	15-Jul-99	454.1	582.4	273.1	374.9	71.1	1755.6	1862.0	94.3
145	16-Jul-99								
146	17-Jul-99								
147	18-Jul-99	438.3	535.4	270.8	398.2	-62.9	1579.7	1794.8	88.0
148	19-Jul-99	301.9	610.4	264.9	428.4	54.6	1660.2	1783.6	93.1
149	20-Jul-99								
150	21-Jul-99	150.7	746.7	238.6	341.9	304.3	1782.2	1643.6	108.4
151	22-Jul-99	56.3	509.4	248.4	270.1	204.8	1289.0	1663.2	77.5
152	23-Jul-99								
BATCH 11 Averages:		***635.8***	***388.5***	***265.9***	***351.1***	***-107.5***	***1533.7***	***1758.8***	***87.4***
153	24-Jul-99								
154	25-Jul-99								

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
155	26-Jul-99	21.0	460.2	242.2	255.6	306.6	1285.6	1769.6	72.7
156	27-Jul-99	20.3	545.0	242.8	331.5	85.9	1225.5	1775.2	69.0
157	28-Jul-99	16.7	637.2	261.9	263.8	48.2	1227.7	1640.8	74.8
158	29-Jul-99								
159	30-Jul-99	40.1	441.3	242.5	253.7	100.8	1078.3	1596.0	67.6
160	31-Jul-99								
161	01-Aug-99								
162	02-Aug-99	86.1	565.5	277.6	517.6	201.1	1647.7	1691.2	97.4
163	03-Aug-99	39.9	665.9	271.2	311.4	97.4	1385.9	1724.8	80.4
164	04-Aug-99								
165	05-Aug-99	47.3	763.7	273.0	278.2	146.5	1508.6	1696.8	88.9
166	06-Aug-99	39.2	667.5	260.2	326.1	97.6	1390.7	1780.8	78.1
BATCH 12 Averages:		***38.8***	***593.3***	***258.9***	***317.2***	***135.5***	***1343.8***	***1709.4***	***78.6***
167	07-Aug-99								
168	08-Aug-99	0.0	326.0	232.7	58.0	33.5	650.2	775.6	83.8
169	09-Aug-99	37.1	724.1	269.0	145.9	112.6	1288.7	1601.6	80.5
170	10-Aug-99	55.1	972.3	256.8	297.1	-224.4	1356.9	1652.0	82.1
171	11-Aug-99	41.2	800.3	266.6	302.2	132.7	1542.9	1699.6	90.8
172	12-Aug-99								
173	13-Aug-99	46.5	936.0	243.2	378.2	9.2	1613.1	1612.8	100.0
174	14-Aug-99								
175	15-Aug-99	20.4	683.3	240.9	402.3	-24.2	1322.7	1352.4	97.8
176	16-Aug-99	23.0	723.5	258.4	340.0	-45.4	1299.4	1601.6	81.1
177	17-Aug-99	13.2	700.1	250.5	394.3	30.3	1388.4	1806.0	76.9
178	18-Aug-99	21.6	764.5	249.1	389.7	-23.3	1401.6	1792.0	78.2
179	19-Aug-99	14.4	913.5	243.9	385.4	-100.4	1456.8	1671.6	87.2
180	20-Aug-99	42.7	780.2	239.7	366.7	85.5	1514.9	1747.2	86.7
181	21-Aug-99								
182	22-Aug-99	80.4	587.9	240.2	408.1	139.5	1456.1	1789.2	81.4
183	23-Aug-99	104.1	577.2	241.5	381.6	170.8	1475.3	1792.0	82.3
184	24-Aug-99	76.7	671.1	243.0	331.4	158.6	1480.8	1761.2	84.1
185	25-Aug-99	62.1	784.5	232.4	363.1	-76.9	1365.2	1730.4	78.9
186	26-Aug-99	49.8	789.1	238.2	361.2	-71.5	1366.8	1778.0	76.9
BATCH 13 Averages:		***43.0***	***733.4***	***246.6***	***331.6***	***19.2***	***1373.7***	***1635.2***	***84.3***
187	27-Aug-99								
188	28-Aug-99								
189	29-Aug-99	13.9	448.5	243.3	327.9	351.5	1385.1	1596.0	86.8
190	30-Aug-99	28.9	307.9	223.7	243.9	403.3	1207.6	1685.6	71.6
191	31-Aug-99	32.5	593.2	227.4	221.5	226.5	1301.1	1632.4	79.7
192	01-Sep-99	47.2	530.8	227.8	272.3	261.7	1339.8	1643.6	81.5
193	02-Sep-99	37.1	398.4	221.5	194.2	309.9	1161.2	1629.6	71.3
194	03-Sep-99	27.9	440.5	235.8	238.9	240.7	1183.7	1607.2	73.7
195	04-Sep-99								
196	05-Sep-99	24.3	594.9	184.1	202.9	239.8	1245.9	1531.6	81.3
197	06-Sep-99	43.4	710.1	213.9	222.3	182.7	1372.4	1640.8	83.6
198	07-Sep-99	27.1	717.4	198.3	227.0	18.7	1188.6	1556.8	76.3
199	08-Sep-99	30.2	572.5	199.6	261.5	122.3	1186.0	1587.6	74.7
200	09-Sep-99	19.0	498.5	209.5	313.0	133.1	1173.1	1612.8	72.7
201	10-Sep-99	14.3	585.4	196.4	289.8	102.2	1188.2	1565.2	75.9
202	11-Sep-99								
203	12-Sep-99								
BATCH 14 Averages:		***28.8***	***533.2***	***215.1***	***251.3***	***216.0***	***1244.4***	***1607.4***	***77.4***
204	13-Sep-99								
205	14-Sep-99								
206	15-Sep-99								

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
207	16-Sep-99	21.8	482.3	224.7	344.5	423.9	1497.1	1825.6	82.0
208	17-Sep-99								
209	18-Sep-99								
210	19-Sep-99	19.0	600.8	222.6	321.3	259.8	1423.5	1895.6	75.1
211	20-Sep-99	12.4	614.4	223.7	329.8	201.5	1381.9	1881.6	73.4
212	21-Sep-99	6.7	586.8	225.2	344.6	261.7	1425.0	1873.2	76.1
213	22-Sep-99	5.1	546.6	217.6	337.8	361.7	1468.8	1724.8	85.2
214	23-Sep-99								
215	24-Sep-99								
216	25-Sep-99								
BATCH 15 Averages:		***13.0***	***566.2***	***222.8***	***335.6***	***301.7***	***1439.3***	***1840.2***	***78.4***
217	26-Sep-99								
218	27-Sep-99								
219	28-Sep-99	20.4	649.8	254.4	260.0	337.8	1522.4	1747.2	87.1
220	29-Sep-99	31.6	730.4	252.7	214.2	301.5	1530.4	1887.2	81.1
221	30-Sep-99	15.2	822.6	250.2	157.9	169.4	1415.3	1719.2	82.3
222	01-Oct-99	12.0	633.0	243.5	110.2	283.3	1282.1	1691.2	75.8
223	02-Oct-99								
224	03-Oct-99	75.6	765.8	266.0	162.2	224.3	1493.9	1677.2	89.1
225	04-Oct-99	59.3	741.6	275.3	182.7	173.7	1432.7	1710.8	83.7
226	05-Oct-99	93.6	744.2	290.5	231.1	286.7	1646.1	1671.6	98.5
227	06-Oct-99	82.5	617.9	276.3	232.8	222.2	1431.9	1654.8	86.5
228	07-Oct-99	75.9	681.0	255.8	177.6	212.6	1402.8	1601.6	87.6
229	08-Oct-99	75.9	643.3	291.0	188.1	229.1	1427.4	1682.8	84.8
230	09-Oct-99								
231	10-Oct-99								
BATCH 16 Averages:		***54.2***	***703.0***	***265.6***	***191.7***	***244.1***	***1458.5***	***1704.4***	***85.7***
232	11-Oct-99								
233	12-Oct-99								
234	13-Oct-99	90.0	472.2	314.8	158.0	337.7	1372.7	1461.6	93.9
235	14-Oct-99	77.8	580.8	267.0	139.9	213.7	1279.2	1268.4	100.8
236	15-Oct-99	96.0	520.4	288.6	181.1	141.3	1227.4	1372.0	89.5
237	16-Oct-99								
238	17-Oct-99	75.9	443.1	293.9	149.9	288.4	1251.2	1346.8	92.9
239	18-Oct-99								
240	19-Oct-99	61.4	662.1	270.2	192.1	160.8	1346.7	1302.0	103.4
241	20-Oct-99	69.4	283.3	234.7	161.6	566.3	1315.3	1248.8	105.3
242	21-Oct-99	126.0	323.1	255.9	155.5	303.2	1163.8	1296.4	89.8
243	22-Oct-99	123.3	553.9	303.5	213.3	259.9	1454.0	1405.6	103.4
244	23-Oct-99								
245	24-Oct-99	155.6	558.3	303.3	214.4	230.0	1461.5	1346.8	108.5
BATCH 17 Averages:		***97.3***	***488.6***	***281.3***	***174.0***	***277.9***	***1319.1***	***1338.7***	***98.6***
246	25-Oct-99								
247	26-Oct-99								
248	27-Oct-99								
249	28-Oct-99	1.5	573.1	219.8	99.4	193.1	1087.0	1380.4	78.7
250	29-Oct-99	58.8	482.2	226.0	123.3	282.4	1172.8	1411.2	83.1
251	30-Oct-99								
252	31-Oct-99	38.1	388.4	237.6	134.9	419.2	1218.2	1369.2	89.0
253	01-Nov-99	47.9	504.7	246.5	112.9	336.6	1248.6	1394.4	89.5
254	02-Nov-99	16.2	510.1	282.4	117.3	278.1	1204.1	1352.4	89.0
255	03-Nov-99	13.7	483.6	276.0	99.7	308.5	1181.4	1369.2	86.3
256	04-Nov-99	33.5	572.5	296.0	99.5	248.5	1250.0	1400.0	89.3
257	05-Nov-99								
258	06-Nov-99								

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
259	07-Nov-99	58.0	458.1	306.4	92.3	350.9	1265.7	1355.2	93.4
BATCH 18 Averages:		***33.5***	***496.6***	***261.3***	***109.9***	***302.2***	***1203.5***	***1379.0***	***87.3***
260	08-Nov-99								
261	09-Nov-99								
262	10-Nov-99								
263	11-Nov-99	69.3	522.1	299.1	218.3	347.4	1456.1	1685.6	86.4
264	12-Nov-99	76.3	523.0	296.5	248.7	307.5	1451.9	1635.2	88.8
265	13-Nov-99								
266	14-Nov-99	32.9	603.7	307.6	239.3	265.0	1448.5	1660.4	87.2
267	15-Nov-99	48.7	494.7	288.7	208.4	441.2	1481.8	1772.4	83.6
268	16-Nov-99								
269	17-Nov-99	15.0	663.6	324.8	290.4	417.4	1711.2	1783.6	95.9
270	18-Nov-99	26.5	517.7	315.9	253.4	395.3	1508.8	1736.0	86.9
271	19-Nov-99	15.5	634.4	307.0	281.1	284.7	1522.6	1741.6	87.4
BATCH 19 Averages:		***40.6***	***565.6***	***305.6***	***248.5***	***351.2***	***1511.6***	***1716.4***	***88.0***
272	20-Nov-99								
273	21-Nov-99	4.6	716.6	276.7	126.0	119.4	1243.4	1405.6	88.5
274	22-Nov-99	36.6	595.2	296.1	105.4	179.0	1212.3	1400.0	86.6
275	23-Nov-99	20.9	415.7	280.8	93.9	337.1	1148.4	1411.2	81.4
276	24-Nov-99	2.5	485.8	283.0	86.7	278.2	1136.2	1439.2	78.9
277	25-Nov-99	2.8	624.0	294.7	83.6	137.2	1142.2	1425.2	80.1
278	26-Nov-99								
279	27-Nov-99								
280	28-Nov-99	7.6	539.1	312.2	88.8	270.5	1218.3	1416.8	86.0
281	29-Nov-99								
282	30-Nov-99	13.6	384.0	314.7	81.5	412.6	1206.4	1416.8	85.2
283	01-Dec-99	11.7	445.4	314.6	97.1	324.1	1192.9	1405.6	84.9
284	02-Dec-99	14.5	443.4	281.1	94.1	336.0	1169.2	1369.2	85.4
BATCH 20 Averages:		***12.8***	***516.6***	***294.9***	***95.2***	***266.0***	***1185.5***	***1410.0***	***84.1***
285	03-Dec-99								
286	04-Dec-99								
287	05-Dec-99	10.1	500.2	292.2	85.7	222.2	1110.4	1349.6	82.3
288	06-Dec-99	9.8	429.6	281.6	86.4	330.0	1137.5	1321.6	86.1
289	07-Dec-99	7.6	408.2	244.8	94.5	368.7	1123.8	1352.4	83.1
290	08-Dec-99	3.5	448.0	276.2	101.6	345.3	1174.6	1338.4	87.8
291	09-Dec-99	3.9	515.5	245.4	85.2	234.9	1084.9	1321.6	82.1
292	10-Dec-99								
293	11-Dec-99								
294	12-Dec-99	6.3	439.8	300.8	94.1	340.3	1181.4	1332.8	88.6
295	13-Dec-99	15.2	418.1	326.7	102.6	353.1	1215.8	1400.0	86.8
296	14-Dec-99								
BATCH 21 Averages:		***8.1***	***451.3***	***281.1***	***92.9***	***313.5***	***1146.9***	***1345.2***	***85.3***
297	15-Dec-99								
298	16-Dec-99								
299	17-Dec-99	31.1	621.0	350.7	108.1	379.8	1490.7	1618.4	92.1
300	18-Dec-99								
301	19-Dec-99	108.4	664.0	318.3	195.9	274.1	1560.8	1615.6	96.6
302	20-Dec-99	109.0	713.3	297.8	204.6	204.0	1528.8	1596.0	95.8
303	21-Dec-99	94.1	764.0	297.4	178.5	157.7	1491.6	1680.0	88.8
304	22-Dec-99	96.9	570.2	302.4	153.2	395.6	1518.3	1604.4	94.6
305	23-Dec-99	87.0	588.8	302.6	181.2	371.7	1531.3	1601.6	95.6
306	24-Dec-99								
307	25-Dec-99								
308	26-Dec-99	96.2	574.0	263.4	196.6	356.0	1486.3	1601.6	92.8
309	27-Dec-99	93.9	637.2	277.8	140.8	306.1	1455.8	1629.6	89.3

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
310	28-Dec-99	75.2	605.5	281.3	136.6	332.3	1430.8	1593.2	89.8
311	29-Dec-99	73.6	608.3	276.1	129.2	356.9	1444.2	1640.8	88.0
BATCH 22 Averages:		***86.5***	***634.6***	***296.8***	***162.5***	***313.4***	***1493.8***	***1618.1***	***92.3***
312	30-Dec-99								
313	31-Dec-99								
314	01-Jan-00								
315	02-Jan-00	39.5	834.1	322.5	423.0	435.5	2054.6	2279.2	90.1
316	03-Jan-00	31.6	971.9	313.4	411.5	255.6	1984.1	2234.4	88.8
317	04-Jan-00	16.5	968.9	265.8	324.7	154.0	1729.9	1607.2	107.6
318	05-Jan-00	42.4	921.7	266.1	178.9	75.1	1484.2	1699.6	87.3
319	06-Jan-00	56.5	825.6	264.4	179.3	125.4	1451.2	1666.0	87.1
320	07-Jan-00	26.0	814.6	275.1	206.2	138.8	1460.7	1688.4	86.5
321	08-Jan-00								
322	09-Jan-00								
323	10-Jan-00	38.4	532.8	248.7	142.2	417.8	1379.9	1694.0	81.5
324	11-Jan-00	52.6	574.8	246.3	155.2	282.7	1311.7	1517.6	86.4
325	12-Jan-00	57.8	561.0	238.8	167.8	329.6	1355.1	1596.0	84.9
326	13-Jan-00	72.6	557.8	243.0	201.1	264.6	1339.1	1472.8	90.9
327	14-Jan-00	81.6	730.5	298.3	177.2	196.1	1483.8	1601.6	92.6
BATCH 23 Averages:		***46.9***	***754.0***	***271.1***	***233.4***	***243.2***	***1548.6***	***1732.4***	***89.4***
328	15-Jan-00								
329	16-Jan-00	49.5	421.7	293.1	130.6	339.7	1234.5	1377.6	89.6
330	17-Jan-00	38.6	427.6	294.3	149.4	263.7	1173.6	1330.0	88.2
331	18-Jan-00	70.3	700.4	337.7	191.7	379.8	1679.8	1890.0	88.9
332	19-Jan-00	33.9	832.3	311.5	159.1	344.0	1680.9	1934.8	86.9
333	20-Jan-00	82.8	534.5	326.7	174.9	546.3	1665.2	1929.2	86.3
334	21-Jan-00	67.5	676.7	309.7	209.0	428.2	1691.2	1909.6	88.6
335	22-Jan-00								
336	23-Jan-00								
337	24-Jan-00	109.2	524.6	313.1	362.8	530.2	1840.0	1848.0	99.6
338	25-Jan-00	104.0	606.7	317.1	246.4	448.9	1723.1	1892.8	91.0
339	26-Jan-00	93.1	779.3	296.8	270.1	120.3	1559.5	1915.2	81.4
340	27-Jan-00								
341	28-Jan-00								
BATCH 24 Averages:		***72.1***	***611.5***	***311.1***	***210.5***	***377.9***	***1583.1***	***1780.8***	***88.9***
342	29-Jan-00								
343	30-Jan-00								
344	31-Jan-00	8.5	475.3	300.0	124.7	208.6	1117.0	1223.6	91.3
345	01-Feb-00	2.2	628.4	288.7	126.5	103.9	1149.6	1324.4	86.8
346	02-Feb-00								
347	03-Feb-00	5.0	675.5	292.5	110.4	84.5	1167.9	1344.0	86.9
348	04-Feb-00	1.3	229.3	308.5	85.3	452.4	1076.8	1344.0	80.1
349	05-Feb-00								
350	06-Feb-00	1.6	253.4	309.9	105.3	490.2	1160.4	1321.6	87.8
351	07-Feb-00	1.2	267.5	329.8	117.1	460.9	1176.6	1355.2	86.8
352	08-Feb-00	1.8	291.0	300.7	105.7	384.1	1083.3	1232.0	87.9
353	09-Feb-00	1.2	349.2	317.7	99.7	376.2	1144.0	1302.0	87.9
354	10-Feb-00	1.9	359.7	320.7	95.0	326.5	1103.8	1313.2	84.1
355	11-Feb-00								
BATCH 25 Averages:		***2.7***	***392.2***	***307.6***	***107.7***	***320.8***	***1131.0***	***1306.7***	***86.6***
356	12-Feb-00								
357	13-Feb-00								
358	14-Feb-00	1.9	514.2	339.5	138.1	479.1	1472.9	1419.6	103.8
359	15-Feb-00	18.5	754.3	349.9	127.9	186.4	1436.9	1498.0	95.9
360	16-Feb-00	7.8	653.3	331.5	130.3	230.8	1353.8	1512.0	89.5

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
361	17-Feb-00	1.1	841.1	322.8	123.5	213.1	1501.8	1808.8	83.0
362	18-Feb-00								
363	19-Feb-00								
364	20-Feb-00	2.0	782.1	335.0	121.0	185.1	1425.2	1663.2	85.7
365	21-Feb-00	5.7	450.1	365.8	97.5	554.0	1473.2	1856.4	79.4
366	22-Feb-00	26.6	569.1	365.7	101.5	356.8	1419.7	1638.0	86.7
367	23-Feb-00	8.6	564.3	357.2	84.8	379.2	1394.1	1652.0	84.4
368	24-Feb-00	12.8	576.6	362.9	100.0	336.1	1388.4	1596.0	87.0
BATCH 26 Averages:		***9.5***	***633.9***	***347.8***	***113.9***	***324.5***	***1429.6***	***1627.1***	***88.4***
369	25-Feb-00								
370	26-Feb-00								
371	27-Feb-00	25.4	302.9	261.8	99.6	447.0	1136.8	1671.6	68.0
372	28-Feb-00	12.4	627.8	281.2	97.3	174.5	1193.4	1254.4	95.1
373	29-Feb-00	25.4	569.6	385.4	87.8	252.0	1320.1	1498.0	88.1
374	01-Mar-00	14.2	592.6	332.4	107.4	188.5	1235.0	1402.8	88.0
375	02-Mar-00	8.5	640.2	334.7	96.0	162.8	1242.2	1366.4	90.9
376	03-Mar-00								
377	04-Mar-00								
378	05-Mar-00	10.5	648.1	337.3	87.8	118.5	1202.1	1450.4	82.9
379	06-Mar-00	10.7	591.9	349.0	91.4	227.1	1270.2	1514.8	83.9
380	07-Mar-00	47.1	641.6	313.0	85.4	182.7	1269.8	1450.4	87.5
381	08-Mar-00								
382	09-Mar-00								
BATCH 27 Averages:		***19.3***	***576.8***	***324.3***	***94.1***	***219.1***	***1233.7***	***1451.1***	***85.6***
383	10-Mar-00								
384	11-Mar-00								
385	12-Mar-00	81.4	1064.7	285.2	170.6	-4.0	1597.8	1811.6	88.2
386	13-Mar-00	68.6	958.3	283.0	151.5	137.7	1599.2	1764.0	90.7
387	14-Mar-00	84.3	850.2	266.9	149.5	205.4	1556.3	1769.6	87.9
388	15-Mar-00	79.5	981.9	250.2	169.9	59.9	1541.3	1778.0	86.7
389	16-Mar-00	104.2	987.0	305.5	180.5	71.2	1648.3	1772.4	93.0
390	17-Mar-00								
391	18-Mar-00								
392	19-Mar-00	90.1	931.5	319.5	182.9	86.3	1610.2	1747.2	92.2
393	20-Mar-00	41.4	872.9	345.3	201.1	139.5	1600.2	1848.0	86.6
394	21-Mar-00	21.2	992.7	351.2	233.8	68.0	1666.7	1887.2	88.3
395	22-Mar-00	15.3	927.4	319.0	225.1	110.3	1597.1	1848.0	86.4
396	23-Mar-00								
397	24-Mar-00								
BATCH 28 Averages:		***65.1***	***951.8***	***302.9***	***185.0***	***97.1***	***1601.9***	***1802.9***	***88.9***
398	25-Mar-00								
399	26-Mar-00	1.7	768.4	298.0	144.2	16.5	1228.8	1327.2	92.6
400	27-Mar-00	11.8	557.4	302.6	122.2	252.7	1246.7	1388.8	89.8
401	28-Mar-00	3.9	597.2	298.6	97.6	267.0	1264.3	1394.4	90.7
402	29-Mar-00	4.3	620.3	294.0	110.3	240.8	1269.7	1447.6	87.7
403	30-Mar-00	4.2	627.7	310.7	118.5	236.2	1297.4	1444.8	89.8
404	31-Mar-00								
405	01-Apr-00								
406	02-Apr-00	17.7	646.8	313.8	91.1	188.4	1257.8	1503.6	83.6
407	03-Apr-00	4.2	537.7	316.4	113.8	290.7	1262.8	1439.2	87.7
BATCH 29 Averages:		***6.8***	***622.2***	***304.9***	***114.0***	***213.2***	***1261.0***	***1420.8***	***88.8***
408	04-Apr-00								
409	05-Apr-00								
410	06-Apr-00	7.4	726.3	294.5	91.1	214.5	1333.8	1500.8	88.9
411	07-Apr-00								

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
412	08-Apr-00								
413	09-Apr-00	6.8	714.2	286.4	87.0	199.1	1293.5	1481.2	87.3
414	10-Apr-00	10.2	768.4	273.2	96.9	172.4	1321.1	1450.4	91.1
415	11-Apr-00	17.6	643.1	287.4	142.4	242.9	1333.5	1509.2	88.4
416	12-Apr-00	18.1	717.5	293.1	133.9	165.5	1328.1	1576.4	84.2
417	13-Apr-00	17.8	774.5	287.7	154.6	167.4	1401.9	1626.8	86.2
418	14-Apr-00								
419	15-Apr-00								
420	16-Apr-00	19.3	786.6	308.9	181.3	155.5	1451.5	1736.0	83.6
421	17-Apr-00								
BATCH 30 Averages:		***13.9***	***732.9***	***290.2***	***126.7***	***188.2***	***1351.9***	***1554.4***	***87.1***
422	18-Apr-00								
423	19-Apr-00								
424	20-Apr-00								
425	21-Apr-00								
426	22-Apr-00								
427	23-Apr-00								
428	24-Apr-00	0.0	701.1	397.9	235.7	139.7	1474.4	1732.5	85.1
429	25-Apr-00	0.0	735.6	362.0	113.1	138.5	1349.2	1568.0	86.0
430	26-Apr-00	0.0	727.7	367.5	115.1	80.5	1290.7	1554.0	83.1
431	27-Apr-00	0.0	805.7	378.1	89.3	45.0	1318.1	1564.5	84.2
432	28-Apr-00	0.0	837.1	392.8	104.0	55.0	1389.0	1613.5	86.1
433	29-Apr-00								
434	30-Apr-00	0.0	797.9	394.5	103.2	106.6	1402.2	1585.5	88.4
435	01-May-00	3.2	719.4	393.4	107.6	151.8	1375.4	1575.0	87.3
436	02-May-00	4.8	757.6	369.2	99.0	133.9	1364.5	1564.5	87.2
437	03-May-00	5.5	722.2	359.3	92.4	179.4	1358.8	1638.0	83.0
438	04-May-00	1.9	787.5	359.5	111.8	280.0	1540.6	1687.0	91.3
BATCH 31 Averages:		***1.5***	***759.2***	***377.4***	***117.1***	***131.0***	***1386.3***	***1608.3***	***86.2***
439	05-May-00								
440	06-May-00								
441	07-May-00								
442	08-May-00	5.2	991.0	392.5	118.8	203.0	1710.5	1970.5	86.8
443	09-May-00	84.2	764.2	384.8	192.0	303.8	1728.9	2002.0	86.4
444	10-May-00	17.4	917.5	377.3	156.9	210.2	1679.4	2019.5	83.2
445	11-May-00	17.2	974.6	366.9	167.9	101.1	1627.7	1998.5	81.4
446	12-May-00	8.0	1012.1	397.1	153.2	67.1	1637.5	1967.0	83.2
447	13-May-00								
448	14-May-00	3.7	1101.3	356.6	150.1	46.9	1658.7	1967.0	84.3
449	15-May-00	50.8	1016.1	344.8	172.1	24.2	1608.0	1998.5	80.5
450	16-May-00								
451	17-May-00	59.0	1085.0	375.7	229.4	-56.0	1693.1	1988.0	85.2
452	18-May-00	54.8	1024.6	382.3	198.4	-14.1	1645.9	1967.0	83.7
453	19-May-00								
454	20-May-00								
455	21-May-00	43.4	1265.1	448.0	272.7	-156.2	1873.0	2096.5	89.3
456	22-May-00								
BATCH 32 Averages:		***34.4***	***1015.2***	***382.6***	***181.2***	***73.0***	***1686.3***	***1997.5***	***84.4***
457	23-May-00								
458	24-May-00								
459	25-May-00								
460	26-May-00								
461	27-May-00								
462	28-May-00								
463	29-May-00								

Day No.	Date	Sum NO2 denitrified mgN/d	Sum NO3 denitrified mgN/d	N Wasted mgN/d	N in Effluent mgN/d	N loss Nitrifier mgN/d	Sum N Out mgN/d	TKN in mgN/d	% Recovery
464	30-May-00								
465	31-May-00								
466	01-Jun-00								
467	02-Jun-00								
468	03-Jun-00								
469	04-Jun-00								
470	05-Jun-00								
BATCH 33 Averages:									
471	06-Jun-00								
472	07-Jun-00								
473	08-Jun-00								
474	09-Jun-00								
475	10-Jun-00								
476	11-Jun-00	40.9	880.6	553.6	504.9	8.3	1988.4	2187.5	90.9
477	12-Jun-00	30.7	1011.1	593.7	564.4	-10.9	2188.9	2219.0	98.6
478	13-Jun-00	22.5	1145.9	669.6	515.4	-101.8	2251.6	2226.0	101.2
479	14-Jun-00	34.8	1032.0	509.7	480.4	-71.8	1985.1	2138.5	92.8
480	15-Jun-00	50.4	1202.4	557.5	497.4	-262.5	2045.2	2170.0	94.3
481	16-Jun-00	46.6	1223.0	515.4	510.2	-314.7	1980.5	2212.0	89.5
482	17-Jun-00								
483	18-Jun-00	49.5	1231.7	522.9	553.0	-315.1	2042.1	2163.0	94.4
BATCH 34 Averages:		***39.4***	***1103.8***	***560.4***	***518.0***	***-152.7***	***2068.8***	***2188.0***	***94.5***

Day No.	Date	COD In mgCOD/d	MOT Consumed mgO/d	O Demand NO2 mgO/d	O Demand NO3 mgO/d	MOC mgO/d	COD used NO2 Denit. mgCOD/d	COD used NO3 Denit. mgCOD/d	COD used Tot. Denit. mgCOD/d	COD used Nitrifier mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	Total COD out mgCOD/d	% Recovery mgCOD/d
1	22-Feb-99													
2	23-Feb-99	15040.0	5397.6	7.1	1339.5	4051.0	162.3	1237.8	1400.2	1687.0	4960.0	648.0	12746.2	84.7
3	24-Feb-99	16400.0	5990.4	0.0	1025.3	4965.1	223.8	1521 8	1745.6	1226.9	4360.0	900.0	13197.6	80.5
4	25-Feb-99													
5	26-Feb-99													
6	27-Feb-99													
7	28-Feb-99													
8	01-Mar-99	14240.0	4648.8	0.0	1016.0	3632.8	99.5	2370.4	2469.9	1226.9	4240.0	1008.0	12577.6	88.3
9	02-Mar-99	15120.0	4024.8	0.0	478.3	3546.5	34.0	2100.3	2134.4	1840.3	3960.0	756.0	12237.2	80.9
10	03-Mar-99													
11	04-Mar-99													
BATCH 1 Averages:		***15200.0***	***5015.4***	***1.8***	***984.8***	***4048.9***	***129.9***	***1807.6***	***1937.5***	***1495.3***	***4380.0***	***828.0***	***12689.6***	***83.6***
12	05-Mar-99													
13	06-Mar-99													
14	07-Mar-99													
15	08-Mar-99													
BATCH 2 Averages:		***Bad Batch***												
16	09-Mar-99													
17	10-Mar-99													
18	11-Mar-99													
19	12-Mar-99													
20	13-Mar-99													
21	14-Mar-99													
22	15-Mar-99													
23	16-Mar-99													
24	17-Mar-99													
25	18-Mar-99													
BATCH 3 Averages:														
26	19-Mar-99													
27	20-Mar-99													
28	21-Mar-99													
29	22-Mar-99	14989.9	4992.0	0.0	1740.8	3251 2	221.6	1924.0	2145.6	5071.0	3166.3	901.8	14535.9	97.0
30	23-Mar-99	14589.1	4586.4	0.0	871.4	3715.0	220.0	1619.8	1839.7	5378.3	3126.2	1010.0	15069 3	103.3
31	24-Mar-99													
32	25-Mar-99	14108.2	5397.6	0.0	2312.2	3085.4	119.2	2356.6	2475.8	5532.0	4008.0	937 9	16039.0	113 7
33	26-Mar-99													
34	27-Mar-99													
35	28-Mar-99													
36	29-Mar-99													
37	30-Mar-99													
38	31-Mar-99													
BATCH 4 Averages:		***14562.4***	***4992.0***	***0.0***	***1641.5***	***3350.5***	***186.9***	***1966.8***	***2153.7***	***5327.1***	***3433.5***	***949.9***	***15214.7***	***104.6***
39	01-Apr-99													
40	02-Apr-99													
41	03-Apr-99													
42	04-Apr-99													
43	05-Apr-99	12685.6	4508.4	0.0	1204.8	3303.6	210.8	1822.1	2032.9	5731.1	3838.0	1127.2	16032.7	126.4
44	06-Apr-99													
45	07-Apr-99													
46	08-Apr-99													
47	09-Apr-99													
48	10-Apr-99													
49	11-Apr-99	11845.3	4352.4	0.0	960.6	3391.8	107.5	1115.1	1222.6	2943.0	3256.2	894.5	11708.0	98.8
50	12-Apr-99													
51	13-Apr-99	11392.8	4321.2	0.0	838.5	3482.7	150.7	1491.2	1641.9	2943.0	3110.8	909.0	12087.4	106.1
52	14-Apr-99													
53	15-Apr-99	11231.2	2652.0	77.2	1040.3	1534.4	138.2	1908.9	2047.1	1703.8	2464.4	690.8	8440.6	75.2
54	16-Apr-99													
BATCH 5 Averages:		***11788.7***	***3958.5***	***19.3***	***1011.1***	***2928.1***	***151.8***	***1584.3***	***1736.1***	***3330.2***	***3187.4***	***905.4***	***12067.2***	***101.6***
55	17-Apr-99													
56	18-Apr-99													
57	19-Apr-99	16725.6	3946.8	0.0	1182.4	2764.4	122.8	1990.9	2113.7	7280.0	3434.0	1127.2	16719.2	100.0
58	20-Apr-99													
59	21-Apr-99													
60	22-Apr-99	15432.8	4461.6	425.6	1226.7	2809.4	259.3	2006.8	2266.1	6660.4	4201.6	1236.2	17173.7	111.3
61	23-Apr-99													
62	24-Apr-99													
63	25-Apr-99													
64	26-Apr-99													
65	27-Apr-99	15401.0	4087.2	352.2	654.5	3080.5	296.5	2403.9	2700.4	314.1	3522.6	1216.5	10834.1	70.3
66	28-Apr-99	12288.0	4071.6	968.5	697.7	2405.3	416.9	1606.1	2022.9	5182.3	3686.4	884.7	14181.7	115.4
67	29-Apr-99	14827.5	4157.4	0.0	2184.7	1972.7	554.2	3095.3	3649.4	2198.6	4055.0	847.9	12723.6	85.8
BATCH 6 Averages:		***14935.0***	***4144.9***	***349.3***	***1189.2***	***2606.5***	***329.9***	***2220.6***	***2550.5***	***4327.1***	***3779.9***	***1062.5***	***14326.5***	***96.6***
68	30-Apr-99													
69	01-May-99													
70	02-May-99													
71	03-May-99	13926.4	3213.6	0.0	206.8	3006.8	99.5	1373.5	1473.0	3769.0	3686.4	1327.1	13262.3	95.2
72	04-May-99	14090.2	2823.6	0.0	793.7	2029.9	372.8	2471.2	2844.1	4868.3	3850.2	1400.8	14993.2	106.4
73	05-May-99	14663.7	3042.0	0.0	663.7	2378.3	290.6	2289.7	2580.4	5967.5	3645.4	553.0	15124.7	103.1
74	06-May-99	16138.2	3198.0	0.0	818.9	2379.1	241.5	2301.8	2543.3	4240.1	3645.4	847.9	13655.8	84.6
75	07-May-99	13025.3	3291.6	0.0	856.8	2434.8	211.5	2136.0	2347.4	3926.0	3317.8	700.4	12726.4	97.7
76	08-May-99													
77	09-May-99	11960.3	3166.8	0.0	754.9	2411.9	169.9	1596.7	1766.6	3926.0	3522.6	811.0	12438.0	104.0
78	10-May-99	14172.2	3432.0	0.0	748.5	2683.5	209.4	1856.3	2065.7	4397.1	3153.9	774.1	13074.4	92.3

Day No.	Date	COD In mgCOD/d	MOT Consumed mgO/d	O Demand NO2 mgO/d	O Demand NO3 mgO/d	MOC mgO/d	COD used NO2 Denit. mgCOD/d	COD used NO3 Denit. mgCOD/d	COD used Tot. Denit. mgCOD/d	COD used Nitrifier mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	Total COD out mgCOD/d	% Recovery mgCOD/d
79	11-May-99	14192.6	3488.2	0.0	746.0	2742.2	249.8	1913.0	2162.8	4792.2	3306.2	580.6	13584.1	95.7
80	12-May-99	13466.9	3299.4	0.0	772.1	2527.3	232.3	2128.1	2360.4	1391.3	3185.3	907.2	10371.5	77.0
81	13-May-99	13305.6	3282.2	0.0	717.7	2564.5	200.1	1775.5	1975.5	2473.4	2701.4	471.7	10186.6	76.6
82	14-May-99													
BATCH 7 Averages:		***13894.1***	***3223.7***	***0.0***	***707.9***	***2515.8***	***227.7***	***1984.2***	***2211.9***	***3975.1***	***3401.5***	***837.4***	***12941.7***	***93.3***
83	15-May-99													
84	16-May-99	16450.6	3285.4	0.0	569.6	2715.8	120.1	2077.3	2197.4	4173.8	2903.0	1016.1	13006.1	79.1
85	17-May-99	15160.3	3475.7	157.3	0.0	3318.3	229.8	1909.0	2138.8	4328.4	2580.5	1306.4	13672.4	90.2
86	18-May-99	16450.6	3432.0	0.0	1465.7	1966.3	336.2	2595.8	2932.0	4946.8	2661.1	798.3	13304.6	80.9
87	19-May-99													
88	20-May-99													
89	21-May-99													
90	22-May-99													
91	23-May-99													
92	24-May-99	15160.3	2946.8	0.0	444.5	2502.3	214.2	2364.6	2578.8	4483.0	3306.2	1233.8	14104.1	93.0
93	25-May-99	14031.4	2964.0	0.0	457.2	2506.8	194.9	2394.9	2589.8	4946.8	2580.5	1306.4	13930.2	99.3
94	26-May-99	14353.9	3134.0	0.0	838.2	2295.9	258.0	2121.5	2379.4	5565.1	2338.6	943.5	13522.5	94.2
95	27-May-99	15644.2	3441.4	0.0	774.6	2666.8	209.2	1951.2	2160.3	5565.1	2177.3	870.9	13440.4	85.9
96	28-May-99													
97	29-May-99													
98	30-May-99													
BATCH 8 Averages:		***15321.6***	***3239.9***	***22.5***	***650.0***	***2567.5***	***223.2***	***2202.0***	***2425.2***	***4858.4***	***2649.6***	***1067.9***	***13568.6***	***88.9***
99	31-May-99													
100	01-Jun-99													
101	02-Jun-99													
102	03-Jun-99													
BATCH 9 Averages:		***Bad Batch***												
103	04-Jun-99													
104	05-Jun-99													
105	06-Jun-99	16515.8	3556.8	0.0	401.2	3155.6	-50.6	652.3	601.7	5076.2	2752.6	1165.8	12752.0	77.2
106	07-Jun-99	16192.0	3793.9	0.0	620.0	3173.9	-6.8	687.7	680.8	4460.9	2347.8	1165.8	11829.3	73.1
107	08-Jun-99	15382.4	3940.6	0.0	747.7	3192.9	-72.5	996.3	923.8	3691.8	2428.8	1238.7	11475.9	74.6
108	09-Jun-99	15706.2	3935.9	0.0	893.6	3042.3	-49.3	906.7	857.4	0.0	2752.6	1603.0	8255.4	52.6
109	10-Jun-99													
110	11-Jun-99													
111	12-Jun-99													
112	13-Jun-99													
113	14-Jun-99													
114	15-Jun-99													
115	16-Jun-99	16596.8	2466.4	601.2	111.7	1753.5	-15.0	288.9	273.8	2845.7	3117.0	1420.8	9410.9	56.7
116	17-Jun-99	15913.0	2452.3	650.4	125.4	1676.5	-2.9	103.9	101.0	1993.3	3190.9	1603.7	8565.3	53.8
117	18-Jun-99													
118	19-Jun-99													
119	20-Jun-99	16990.4	2383.7	709.6	145.8	1528.3	648.2	99.1	747.3	2606.6	2279.2	1156.2	8317.5	49.0
120	21-Jun-99	15830.1	2260.4	315.4	95.7	1849.4	534.3	96.9	631.2	3373.2	1781.9	559.4	8195.2	51.8
121	22-Jun-99	16410.2	2143.4	749.0	113.1	1281.3	438.4	112.1	550.5	1993.3	2486.4	1044.3	7355.8	44.8
122	23-Jun-99	16327.4	1946.9	-39.4	290.6	1695.7	477.9	192.3	670.1	3219.9	1781.9	1007.0	8374.6	51.3
123	24-Jun-99													
124	25-Jun-99													
125	26-Jun-99													
126	27-Jun-99													
127	28-Jun-99	16045.6	2140.3	-282.1	121.4	2300.9	951.7	119.7	1071.4	2146.6	2884.2	954.8	9358.0	58.3
128	29-Jun-99													
129	30-Jun-99	15498.6	1717.6	-802.8	560.8	1959.5	1026.4	415.2	1441.6	4599.8	2362.1	783.2	11146.2	71.9
130	01-Jul-99	15913.0	1989.0	-585.8	364.3	2210.5	1063.9	272.3	1336.1	2453.2	2072.0	820.5	8892.4	55.9
131	02-Jul-99	14504.0	1950.0	-661.7	188.0	2423.8	1010.4	202.9	1213.2	3526.5	2196.3	1156.2	10516.1	72.5
132	03-Jul-99													
133	04-Jul-99													
134	05-Jul-99													
BATCH 10 Averages:		***15987.5***	***2619.8***	***46.7***	***341.4***	***2231.7***	***425.3***	***367.6***	***792.9***	***2999.1***	***2459.6***	***1120.0***	***9603.2***	***60.2***
135	06-Jul-99	16891.2	3012.4	238.7	607.0	2166.7	1494.0	386.8	1880.8	0.0	3304.8	1211.8	8564.1	50.7
136	07-Jul-99	21868.8	3107.5	-420.5	1211.0	2317.0	1500.4	603.0	2103.4	0.0	3672.0	1542.2	9634.7	44.1
137	08-Jul-99	14769.6	3442.9	-186.9	779.3	2850.6	1501.9	343.9	1845.9	0.0	3794.4	1579.0	10069.6	68.2
138	09-Jul-99	14116.8	3154.3	-514.0	1166.8	2501.5	1579.6	528.1	2107.7	0.0	3794.4	1799.3	10202.8	72.3
139	10-Jul-99	14035.2	3269.8	-747.6	1237.1	2780.3	1479.6	587.0	2066.6	3258.3	3753.6	1542.2	13401.0	95.5
140	11-Jul-99	15667.2	2965.6	-969.5	1340.0	2595.1	1379.6	654.1	2033.7	1332.9	3916.8	1248.5	11127.0	71.0
141	12-Jul-99													
142	13-Jul-99	15214.4	2995.2	-1303.2	2226.5	2071.9	1396.2	1525.4	2921.6	1343.4	4070.9	1147.2	11555.1	75.9
143	14-Jul-99	16365.8	2970.2	-657.2	2010.7	1616.7	1406.2	1281.1	2687.2	1791.2	3659.7	1739.4	11494.2	70.2
144	15-Jul-99	16036.8	3843.8	668.3	3056.6	119.0	776.5	1665.6	2442.1	2686.8	3577.4	1665.4	10490.6	65.4
145	16-Jul-99													
146	17-Jul-99													
147	18-Jul-99	13322.9	4076.3	1102.7	2297.2	676.4	749.5	1531.1	2280.6	2239.0	3947.5	1258.3	10401.7	78.1
148	19-Jul-99	16612.5	3937.4	534.6	2228.6	1174.2	516.3	1745.7	2262.0	2239.0	3618.6	1406.3	10700.1	64.4
149	20-Jul-99													
150	21-Jul-99	14837.8	5070.0	-108.5	-1121.1	6299.6	257.8	2135.6	2393.4	3805.4	3548.2	1524.1	17570.6	118.4
151	22-Jul-99	13870.1	2603.6	-6.8	162.4	2448.0	96.2	1457.0	1553.3	4976.3	3145.0	870.9	12993.4	93.7
152	23-Jul-99													
BATCH 11 Averages:		***15662.2***	***3419.2***	***-182.3***	***1323.2***	***2278.2***	***1087.2***	***1111.1***	***2198.3***	***1820.9***	***3677.2***	***1425.7***	***11400.4***	***74.5***
153	24-Jul-99													
154	25-Jul-99													
155	26-Jul-99	16692.5	2121.6	-13.6	-77.8	2213.0	35.9	1316.3	1352.2	1610.0	2943.4	834.6	8953.1	53.6
156	27-Jul-99	16853.8	2304.1	-13.6	-173.7	2491.4	34.7	1558.7	1593.4	1756.3	2943.4	1995.8	10780.3	64.0
157	28-Jul-99	15563.5	2577.1	-27.1	-424.1	3028.3	28.5	1822.3	1850.8	1171.1	2960.6	1332.3	10343.2	66.5

Day No.	Date	COD In mgCOD/d	MOT Consumed mgO/d	O Demand NO2 mgO/d	O Demand NO3 mgO/d	MOC mgO/d	COD used NO2 Denit. mgCOD/d	COD used NO3 Denit mgCOD/d	COD used Tot. Denit. mgCOD/d	COD used Nitrifier mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	Total COD out mgCOD/d	% Recovery mgCOD/d
158	29-Jul-99													
159	30-Jul-99	13158.4	2584.9	-54.3	53.1	2586.1	68.5	1262.0	1330.5	146.4	3659.7	851.2	8573.8	65.2
160	31-Jul-99													
161	01-Aug-99													
162	02-Aug-99	15214.4	2542.8	-169.1	408.4	2303.6	147.2	1617.2	1764.4	2195.8	3700.8	1258.3	11222.9	73.8
163	03-Aug-99	15790.1	2533.4	-117.1	-698.0	3348.5	68.3	1904.6	1972.8	1610.3	3371.8	888.2	11191.6	70.9
164	04-Aug-99													
165	05-Aug-99	14581.8	2542.8	26.0	453.3	2063.5	80.8	2184.2	2265.1	1604.0	3522.6	1032.2	10487.3	71.9
166	06-Aug-99	14417.9	2527.2	-52.0	-327.2	2906.4	67.1	1909.2	1976.2	2333.1	3768.3	811.0	11795.0	81.8
BATCH 12 Averages:		***15284.0***	***2466.7***	***-52.6***	***-98.2***	***2617.6***	***66.4***	***1696.8***	***1763.2***	***1553.4***	***3358.8***	***1125.4***	***10418.4***	***68.4***
167	07-Aug-99													
168	08-Aug-99	14499.8	1881.4	0.0	0.0	1881.4	0.0	932.4	932.4	1895.6	3604.5	1032.2	9346.1	64.5
169	09-Aug-99	12697.6	2235.5	-110.7	-325.3	2671.5	63.4	2070.9	2134.3	1458.2	3973.1	995.3	11232.4	88.5
170	10-Aug-99	15482.9	2327.5	-169.3	18.7	2478.1	94.1	2780.8	2874.9	2187.3	4014.1	884.7	12439.1	80.3
171	11-Aug-99	19005.4	2547.5	-117.2	747.1	1917.6	70.4	2288.9	2359.3	1895.6	3317.8	1069.1	10559.3	55.6
172	12-Aug-99													
173	13-Aug-99	16188.5	1921.9	-110.7	1429.9	602.7	79.6	2677.1	2756.6	2183.0	3761.0	1545.3	10848.6	67.0
174	14-Aug-99													
175	15-Aug-99	12672.8	1639.6	-53.4	456.0	1237.0	34.8	1954.4	1989.2	1018.7	2820.7	772.6	7838.3	61.9
176	16-Aug-99	18396.0	2007.7	-53.4	-14.3	2075.5	39.3	2069.1	2108.4	2037.5	3229.5	735.8	10186.7	55.4
177	17-Aug-99	17987.2	2020.2	-26.7	35.6	2011.3	22.6	2002.4	2024.9	2765.1	3352.2	809.4	10962.9	60.9
178	18-Aug-99	15697.9	2248.0	-53.4	370.5	1930.9	37.0	2186.4	2223.3	2910.7	3229.5	699.0	10993.4	70.0
179	19-Aug-99	16188.5	2092.0	-13.4	381.2	1724.1	24.6	2612.7	2637.2	3492.8	3556.6	846.2	12256.9	75.7
180	20-Aug-99	14471.5	2109.1	-80.1	748.1	1441.1	73.1	2231.5	2304.6	3056.2	3393.0	993.4	11188.3	77.3
181	21-Aug-99													
182	22-Aug-99	14635.0	2346.2	-199.3	-178.9	2724.5	137.5	1681.4	1818.9	2765.1	3433.9	1177.3	11919.8	81.4
183	23-Aug-99	15903.2	2201.2	-225.9	174.0	2253.1	178.0	1650.7	1828.7	2493.4	3666.8	1149.5	11391.5	71.6
184	24-Aug-99	15573.6	2305.7	-179.4	344.8	2140.2	131.2	1919.4	2050.6	2493.4	3584.4	1594.4	11863.1	76.2
185	25-Aug-99	15408.8	2265.1	-172.7	-23.9	2461.7	106.2	2243.8	2350.0	2493.4	3378.4	1186.6	11870.1	77.0
186	26-Aug-99	15079.2	2215.2	-146.2	-546.1	2907.4	85.1	2256.7	2341.8	2493.4	3543.2	1186.6	12472.4	82.7
BATCH 13 Averages:		***15618.0***	***2147.7***	***-107.0***	***226.1***	***2028.6***	***73.5***	***2097.4***	***2170.9***	***2352.5***	***3491.2***	***1042.3***	***11085.6***	***71.6***
187	27-Aug-99													
188	28-Aug-99													
189	29-Aug-99	13530.1	2255.8	-13.2	519.9	1749.1	23.8	1282.8	1306.6	3388.7	3427.8	786.1	10658.3	78.8
190	30-Aug-99	16908.5	2262.0	-65.9	-358.6	2686.6	49.4	880.6	930.0	4037.6	2884.0	667.4	11205.6	66.3
191	31-Aug-99	15408.8	2187.1	-79.1	635.6	1630.6	55.6	1696.7	1752.3	2451.4	3254.8	630.4	9719.5	63.1
192	01-Sep-99	15491.2	2567.8	-131.9	175.7	2523.9	80.7	1518.1	1598.8	3591.0	3283.2	738.7	11735.7	75.8
193	02-Sep-99	15349.0	2227.7	-105.5	-82.7	2415.9	63.4	1139.6	1203.0	3160.1	3406.3	701.8	10887.0	70.9
194	03-Sep-99	14199.8	2184.0	-79.1	-229.4	2492.6	47.8	1259.9	1307.7	2441.9	3406.3	849.5	10498.0	73.9
195	04-Sep-99													
196	05-Sep-99	12640.3	1452.5	46.5	417.8	988.2	41.5	1701.4	1742.9	2729.2	3160.1	775.7	9396.0	74.3
197	06-Sep-99	14774.4	1669.4	-106.3	818.8	956.9	74.1	2030.8	2105.0	3447.4	2872.8	886.5	10268.5	69.5
198	07-Sep-99	13789.4	1504.3	-66.4	229.6	1341.2	46.3	2051.9	2098.2	3591.0	2872.8	591.0	10494.1	76.1
199	08-Sep-99	14364.0	1336.3	-66.4	116.7	1286.0	51.7	1637.2	1688.9	3878.3	2995.9	480.2	10329.3	71.9
200	09-Sep-99	14528.2	1293.1	-39.9	-398.4	1731.4	32.5	1425.8	1458.3	3863.2	2739.0	551.9	10343.6	71.2
201	10-Sep-99	10710.6	1153.9	-19.9	308.7	865.1	24.5	1674.4	1698.9	3147.8	2943.4	809.4	9464.5	88.4
202	11-Sep-99													
203	12-Sep-99													
BATCH 14 Averages:		***14307.9***	***1841.2***	***-60.6***	***179.5***	***1722.3***	***49.3***	***1524.9***	***1574.2***	***3310.6***	***3103.9***	***705.7***	***10416.7***	***73.3***
204	13-Sep-99													
205	14-Sep-99													
206	15-Sep-99													
207	16-Sep-99	14471.5	1267.2	46.2	695.9	525.1	37.2	1379.3	1416.5	3290.8	2371.0	956.6	8560.0	59.2
208	17-Sep-99													
209	18-Sep-99													
210	19-Sep-99	14880.3	1345.0	-26.4	58.9	1312.5	32.4	1718.4	1750.8	3433.9	2657.2	1140.6	10295.0	69.2
211	20-Sep-99	15207.4	1366.1	-19.8	-139.3	1525.2	21.3	1757.3	1778.5	3290.8	2943.4	1030.2	10568.1	69.5
212	21-Sep-99	14716.8	1413.1	0.0	47.3	1365.8	11.4	1678.2	1689.7	3720.1	3147.8	919.8	10843.1	73.7
213	22-Sep-99	13490.4	1444.8	13.2	266.5	1165.1	8.7	1563.3	1572.1	3160.1	2913.8	701.8	9512.9	70.5
214	23-Sep-99													
215	24-Sep-99													
216	25-Sep-99													
BATCH 15 Averages:		***14553.3***	***1367.2***	***2.6***	***185.9***	***1178.7***	***22.2***	***1619.3***	***1641.5***	***3379.2***	***2806.6***	***949.8***	***9955.8***	***68.4***
217	26-Sep-99													
218	27-Sep-99													
219	28-Sep-99	16333.9	1429.4	-43.3	326.4	1146.4	34.9	1858.3	1893.2	4550.5	3324.2	849.5	11764.0	72.0
220	29-Sep-99	16580.2	1807.7	-43.3	438.3	1412.7	54.0	2089.0	2143.0	7308.4	3365.3	1034.2	15263.7	92.1
221	30-Sep-99	14610.2	1807.7	-14.4	489.3	1332.8	25.9	2352.6	2378.6	3861.0	3775.7	591.0	11939.1	81.7
222	01-Oct-99	14774.4	1994.9	-28.9	-73.4	2097.2	20.5	1810.3	1830.8	2757.9	3980.9	775.7	11442.4	77.4
223	02-Oct-99													
224	03-Oct-99	14827.5	2202.2	-202.3	582.9	1821.6	129.3	2190.3	2319.5	2890.1	4096.0	811.0	11938.3	80.5
225	04-Oct-99	14909.4	2115.8	-169.6	-249.3	2534.8	101.5	2121.0	2222.5	3165.4	4505.6	958.5	13386.7	89.8
226	05-Oct-99	14581.8	2029.4	-244.3	919.6	1354.1	160.0	2128.5	2288.5	3165.4	4341.8	863.6	11813.3	81.0
227	06-Oct-99	15319.0	2016.0	-210.4	12.9	2213.5	141.1	1767.3	1908.4	3440.6	4218.9	626.7	12408.1	81.0
228	07-Oct-99	14008.3	2014.1	-176.4	56.8	2133.7	129.7	1947.7	2077.4	3027.8	4218.9	774.1	12231.9	87.3
229	08-Oct-99	15810.6	2108.2	-135.7	2.6	2241.3	129.8	1839.9	1969.7	3027.6	4177.9	589.8	12006.5	75.9
230	09-Oct-99													
231	10-Oct-99													
BATCH 16 Averages:		***15175.5***	***1952.5***	***-128.9***	***250.6***	***1828.8***	***92.7***	***2010.5***	***2103.2***	***3719.5***	***4000.5***	***767.4***	***12419.4***	***81.9***
232	11-Oct-99													
233	12-Oct-99													
234	13-Oct-99	13312.2	1990.1	-265.3	312.8	1942.7	153.9	1350.4	1504.3	592.4	4672.5	872.8	9584.7	72.0
235	14-Oct-99	14722.7	2423.0	-227.4	588.6	2061.9	133.0	1661.2	1794.2	2814.1	4540.2	912.5	12122.9	82.3
236	15-Oct-99	13841.1	2069.8	-212.3	180.9	2101.2	164.2	1488.4	1652.7	3110.3	4584.3	952.1	12400.6	89.6

Day No.	Date	COD In mgCOD/d	MOT Consumed mgO/d	O Demand NO2 mgO/d	O Demand NO3 mgO/d	MOC mgO/d	COD used NO2 Denit. mgCOD/d	COD used NO3 Denit. mgCOD/d	COD used Tot. Denit. mgCOD/d	COD used Nitrifier mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	Total COD out mgCOD/d	% Recovery mgCOD/d
237	16-Oct-99													
238	17-Oct-99	13400.3	2157.1	-189.5	374.9	1971.8	129.8	1267.3	1397.1	2666.0	4716.6	912.5	11663.8	87.0
239	18-Oct-99													
240	19-Oct-99	12729.6	2276.2	-159.2	579.2	1856.1	105.1	1893.6	1998.7	2467.6	3427.2	807.8	10557.5	82.9
241	20-Oct-99	13627.2	2493.1	-174.7	838.8	1828.9	118.7	810.2	928.9	2741.8	3794.4	1211.8	10505.7	77.1
242	21-Oct-99	12648.0	2363.5	-341.7	-187.6	2892.8	215.5	924.0	1139.5	2467.6	3590.4	881.3	10971.6	86.7
243	22-Oct-99	12892.8	2243.5	-235.4	515.7	1963.2	210.9	1584.2	1795.1	3221.6	3876.0	697.7	11553.6	89.6
244	23-Oct-99													
245	24-Oct-99	12403.2	2161.9	-364.5	485.7	2040.8	266.1	1596.7	1862.8	3564.3	3631.2	771.1	11870.2	95.7
BATCH 17 Averages:		***13286.3***	***2242.0***	***-241.1***	***409.9***	***2073.3***	***166.4***	***1397.3***	***1563.7***	***2827.3***	***4092.5***	***891.1***	***11247.8***	***84.8***
246	25-Oct-99													
247	26-Oct-99													
248	27-Oct-99													
249	28-Oct-99	15259.2	1243.2	0.0	257.1	986.1	2.7	1639.2	1641.8	3015.9	3141.6	624.2	9409.7	61.7
250	29-Oct-99	15789.6	1183.7	-197.4	79.4	1301.7	100.5	1379.2	1479.7	2878.8	3264.0	807.8	9732.1	61.6
251	30-Oct-99													
252	31-Oct-99	14932.8	1392.0	14.2	400.3	977.5	65.2	1110.8	1176.0	3290.1	3223.2	771.1	9437.9	63.2
253	01-Nov-99	15422.4	1622.4	-127.9	662.6	1087.7	81.8	1443.5	1525.3	4249.7	3141.6	1064.9	11069.3	71.8
254	02-Nov-99	15912.0	2211.8	-21.3	338.3	1894.9	27.6	1459.0	1486.6	2878.8	4365.6	844.6	11470.5	72.1
255	03-Nov-99	16483.2	2149.4	-7.1	264.7	1891.9	23.4	1383.0	1406.4	2604.7	4651.2	881.3	11435.4	69.4
256	04-Nov-99	14663.7	2192.6	-92.4	159.5	2125.5	57.2	1637.3	1694.5	3578.3	4218.9	700.4	12317.6	84.0
257	05-Nov-99													
258	06-Nov-99													
259	07-Nov-99	12779.5	1683.8	-127.9	370.9	1440.8	99.2	1310.3	1409.5	3991.1	4587.5	663.6	12092.5	94.6
BATCH 18 Averages:		***15155.3***	***1709.9***	***-70.0***	***316.6***	***1463.3***	***57.2***	***1420.3***	***1477.5***	***3310.9***	***3824.2***	***794.7***	***10870.6***	***72.3***
260	08-Nov-99													
261	09-Nov-99													
262	10-Nov-99													
263	11-Nov-99	13871.5	1710.7	-142.5	-70.2	1923.4	118.4	1493.2	1611.6	3171.6	3980.9	701.8	11389.2	82.1
264	12-Nov-99	13132.8	1777.0	-156.7	23.1	1910.6	130.5	1495.8	1626.3	2482.1	4432.3	1034.2	11485.5	87.5
265	13-Nov-99													
266	14-Nov-99	12817.0	1646.4	-42.7	149.8	1539.3	56.3	1726.5	1782.8	2453.1	4461.6	1314.1	11551.0	90.1
267	15-Nov-99	14277.1	1740.5	142.5	-171.2	1769.3	83.3	1415.0	1498.2	2316.8	3853.2	766.6	10204.1	71.5
268	16-Nov-99													
269	17-Nov-99	14114.9	1834.6	0.0	542.5	1292.0	25.7	1898.0	1923.6	1635.4	4542.7	803.1	10197.0	72.2
270	18-Nov-99	14196.0	1730.9	-29.3	-101.0	1861.2	45.2	1480.6	1525.9	1499.1	4218.2	876.1	9980.5	70.3
271	19-Nov-99	13483.4	1764.5	-14.6	107.0	1672.1	26.5	1814.3	1840.8	1945.6	4218.7	670.0	10347.3	76.7
BATCH 19 Averages:		***13698.9***	***1743.5***	***-34.8***	***68.6***	***1709.7***	***69.4***	***1617.6***	***1687.1***	***2214.8***	***4244.0***	***880.8***	***10736.4***	***78.6***
272	20-Nov-99													
273	21-Nov-99	15137.8	1801.0	22.0	390.8	1388.2	7.9	2049.5	2057.4	2918.4	3681.0	558.4	10603.4	70.0
274	22-Nov-99	15882.2	1801.9	-102.5	206.5	1697.9	62.6	1702.2	1764.8	3196.3	4880.5	818.9	12358.4	77.8
275	23-Nov-99	15137.8	1720.3	-61.7	8.9	1773.1	35.8	1188.9	1224.7	1806.6	3846.5	632.8	9283.8	61.3
276	24-Nov-99	15468.6	1903.7	5.1	9.0	1889.5	4.3	1389.4	1393.7	2640.4	4384.2	818.9	11126.8	71.9
277	25-Nov-99	16461.3	1990.1	-1.5	81.2	1910.3	4.8	1784.5	1789.4	2501.5	4756.4	856.2	11813.7	71.8
278	26-Nov-99													
279	27-Nov-99													
280	28-Nov-99	15055.0	1819.2	9.5	98.2	1711.4	13.0	1541.8	1554.8	2918.4	4425.5	632.8	11242.9	74.7
281	29-Nov-99													
282	30-Nov-99	15043.8	1867.2	41.4	118.0	1707.8	23.3	1098.3	1121.6	3296.6	4823.8	956.6	11906.4	79.1
283	01-Dec-99	15779.7	1914.2	40.0	106.3	1768.0	20.0	1273.8	1293.8	3296.6	4763.0	993.4	12134.7	76.9
284	02-Dec-99	12999.8	1984.3	42.2	122.8	1819.3	24.8	1268.2	1293.0	3159.2	4823.8	809.4	11904.8	91.6
BATCH 20 Averages:		***15218.5***	***1866.9***	***-0.6***	***126.9***	***1740.6***	***21.8***	***1477.4***	***1499.3***	***2859.3***	***4489.4***	***786.4***	***11375.0***	***75.0***
285	03-Dec-99													
286	04-Dec-99													
287	05-Dec-99	14635.0	1823.0	34.0	106.4	1682.6	17.3	1430.6	1447.9	2884.5	4455.9	919.8	11390.7	77.8
288	06-Dec-99	14798.6	1774.1	3.0	134.2	1636.9	16.8	1228.7	1245.5	2609.8	4537.7	772.6	10802.5	73.0
289	07-Dec-99	14471.5	1700.2	19.9	165.3	1514.9	13.0	1167.5	1180.5	2609.8	4169.8	662.3	10137.2	70.0
290	08-Dec-99	13979.7	1738.6	9.3	138.9	1590.4	6.0	1281.1	1287.1	1945.6	4797.8	818.9	10439.8	74.7
291	09-Dec-99	16957.6	1806.7	11.4	124.8	1670.5	6.6	1474.4	1481.0	2501.5	4880.5	893.4	11426.8	67.4
292	10-Dec-99													
293	11-Dec-99													
294	12-Dec-99	14724.2	1853.8	7.8	83.3	1762.7	10.8	1257.9	1268.6	2640.4	4839.1	856.2	11367.0	77.2
295	13-Dec-99	15303.2	1912.3	1.8	141.9	1768.6	26.1	1195.7	1221.8	1945.6	4921.8	781.7	10639.6	69.5
296	14-Dec-99													
BATCH 21 Averages:		***14981.4***	***1801.2***	***12.5***	***127.8***	***1660.9***	***13.8***	***1290.9***	***1304.6***	***2448.2***	***4657.5***	***815.0***	***10886.2***	***72.8***
297	15-Dec-99													
298	16-Dec-99													
299	17-Dec-99	14393.3	1775.0	-87.8	210.1	1652.8	53.1	1776.0	1829.1	1250.7	5128.6	521.1	10382.4	72.1
300	18-Dec-99													
301	19-Dec-99	14558.7	1683.8	-155.5	290.9	1548.4	185.4	1899.1	2084.5	2501.5	4136.0	521.1	10791.5	74.1
302	20-Dec-99	15220.5	1451.5	-177.4	273.6	1355.3	186.4	2040.1	2226.5	1250.7	4301.4	744.5	9878.4	64.9
303	21-Dec-99	14393.3	1585.0	-223.1	362.4	1445.6	160.8	2185.1	2345.9	2501.5	4591.0	707.3	11591.2	80.5
304	22-Dec-99	14641.4	1694.4	-219.9	443.6	1470.7	165.7	1630.8	1796.5	2779.4	4425.5	856.2	11328.2	77.4
305	23-Dec-99	14558.7	1657.9	-231.0	483.5	1405.4	148.8	1684.0	1832.8	5419.8	3970.6	818.9	13447.5	92.4
306	24-Dec-99													
307	25-Dec-99													
308	26-Dec-99	14227.8	1487.0	-275.3	316.6	1445.7	164.5	1641.8	1806.3	2501.5	3722.4	1042.3	10518.1	73.9
309	27-Dec-99	14145.1	1586.9	-268.0	316.8	1538.0	160.5	1822.4	1982.9	2918.4	3929.2	781.7	11150.2	78.8
310	28-Dec-99	13979.7	1685.8	-214.4	265.5	1634.6	128.5	1731.7	1860.2	2501.5	3970.6	670.0	10636.8	76.1
311	29-Dec-99	13483.4	1729.0	-218.1	200.1	1746.9	125.9	1739.9	1865.8	3335.3	4632.3	1042.3	12622.5	93.6
BATCH 22 Averages:		***14360.2***	***1633.6***	***-207.0***	***316.3***	***1524.3***	***148.0***	***1815.1***	***1963.1***	***2696.0***	***4280.8***	***770.5***	***11234.7***	***78.4***
312	30-Dec-99													
313	31-Dec-99													
314	01-Jan-00													

Day No.	Date	COD In mgCOD/d	MOT Consumed mgO/d	O Demand NO2 mgO/d	O Demand NO3 mgO/d	MOC mgO/d	COD used NO2 Denit. mgCOD/d	COD used NO3 Denit. mgCOD/d	COD used Tot. Denit mgCOD/d	COD used Nitrifier mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	Total COD out mgCOD/d	% Recovery mgCOD/d
315	02-Jan-00	13648.8	1733.8	69.4	453.6	1210.7	67.5	2385.5	2453.1	1806.6	4053.3	744.5	10268.2	75.2
316	03-Jan-00	15220.5	1712.6	87.6	661.9	963.1	54.1	2779.7	2833.8	1806.6	3308.8	818.9	9731.2	63.9
317	04-Jan-00	15055.0	1739.5	-18.3	701.9	1055.9	28.2	2771.0	2799.2	3057.3	3557.0	1042.3	11511.7	76.5
318	05-Jan-00	15096.0	1658.9	-84.0	627.7	1115.2	72.5	2636.1	2708.6	2467.6	3345.6	954.7	10591.7	70.2
319	06-Jan-00	14443.2	1610.9	-109.6	550.5	1170.0	96.7	2361.1	2457.8	2741.8	2937.6	734.4	10041.5	69.5
320	07-Jan-00	14443.2	1488.0	-14.6	494.7	1007.9	44.4	2329.8	2374.2	2056.3	3100.8	514.1	9053.3	62.7
321	08-Jan-00													
322	09-Jan-00													
323	10-Jan-00	14443.2	1555.2	-96.4	290.9	1360.7	65.7	1523.7	1589.4	3427.2	2896.8	697.7	9971.7	69.0
324	11-Jan-00	15259.2	1632.0	-118.6	371.3	1379.3	89.9	1644.0	1733.9	3838.5	3100.8	954.7	11007.2	72.1
325	12-Jan-00	14361.6	1464.0	-85.2	133.9	1415.4	98.8	1604.6	1703.5	2878.8	2896.8	550.8	9445.3	65.8
326	13-Jan-00	14688.0	1382.4	-59.3	129.8	1311.9	124.2	1595.3	1719.5	2878.8	2937.6	440.6	9288.5	63.2
327	14-Jan-00	12240.0	1969.0	-240.9	361.6	1848.3	139.6	2089.3	2228.9	1508.0	4732.8	734.4	11052.3	90.3
BATCH 23 Averages:		***14445.3***	***1631.5***	***-60.9***	***434.3***	***1258.0***	***80.1***	***2156.4***	***2236.5***	***2588.0***	***3351.6***	***744.3***	***10178.4***	***70.8***
328	15-Jan-00													
329	16-Jan-00	10855.7	1618.6	-138.6	224.9	1532.3	84.6	1206.0	1290.6	2210.6	4564.3	703.2	10301.0	94.9
330	17-Jan-00	10691.2	1736.6	-88.7	253.8	1571.6	66.0	1222.8	1288.8	1934.3	4605.4	592.1	9992.2	93.5
331	18-Jan-00	15296.6	1951.7	-68.4	226.7	1793.4	120.2	2003.2	2123.4	2072.4	4358.7	814.2	11162.1	73.0
332	19-Jan-00	16283.5	2974.1	-79.5	623.1	2430.5	57.9	2380.5	2438.5	3039.6	4194.2	888.2	12990.9	79.8
333	20-Jan-00	15049.9	2733.1	-175.6	294.2	2614.5	141.7	1528.7	1670.3	2072.4	4276.5	1110.2	11744.0	78.0
334	21-Jan-00	14392.0	2189.8	-134.9	481.0	1843.6	115.5	1935.4	2050.9	967.1	4276.5	1036.2	10174.4	70.7
335	22-Jan-00													
336	23-Jan-00													
337	24-Jan-00	14806.9	2340.5	-257.6	142.8	2455.3	186.8	1500.4	1687.2	2084.5	4177.4	856.2	11260.6	76.0
338	25-Jan-00	16047.7	2161.0	-272.4	66.1	2367.2	177.8	1735.2	1913.0	1945.6	4384.2	893.4	11503.3	71.7
339	26-Jan-00	15055.0	1968.0	-268.7	-259.6	2496.2	159.2	2228.8	2388.1	694.8	3639.7	744.5	9963.3	66.2
340	27-Jan-00													
341	28-Jan-00													
BATCH 24 Averages:		***14275.4***	***2185.9***	***-164.9***	***228.1***	***2122.7***	***123.3***	***1749.0***	***1872.3***	***1891.3***	***4275.2***	***848.7***	***11010.2***	***78.2***
342	29-Jan-00													
343	30-Jan-00													
344	31-Jan-00	13566.1	1572.5	23.9	240.8	1307.8	14.5	1359.5	1374.0	2362.5	4177.4	707.3	9928.9	73.2
345	01-Feb-00	16378.6	1671.4	3.7	251.7	1415.9	3.7	1797.3	1801.0	2501.5	4218.7	670.0	10607.1	64.8
346	02-Feb-00													
347	03-Feb-00	15096.0	1820.2	1.8	93.8	1724.5	8.6	1932.0	1940.6	2056.3	4406.4	807.8	10935.7	72.4
348	04-Feb-00	15096.0	1915.2	3.9	10.5	1900.7	2.2	655.7	657.9	2741.8	3835.2	367.2	9502.8	62.9
349	05-Feb-00													
350	06-Feb-00	14851.2	1764.5	0.0	146.2	1618.3	2.7	724.9	727.5	2330.5	4896.0	954.7	10527.0	70.9
351	07-Feb-00	15667.2	1891.2	0.0	166.0	1725.2	2.0	765.2	767.2	2193.4	4977.6	1101.6	10765.0	68.7
352	08-Feb-00	15605.8	1909.4	3.9	46.1	1859.4	3.1	832.4	835.4	2594.5	5323.8	987.6	11600.6	74.3
353	09-Feb-00	14955.5	2059.2	3.9	69.8	1985.4	2.1	998.6	1000.7	2594.5	4958.1	1024.1	11562.7	77.3
354	10-Feb-00	15524.5	2346.2	3.9	65.9	2276.4	3.2	1028.8	1031.9	2731.0	4795.5	877.8	11712.7	75.4
355	11-Feb-00													
BATCH 25 Averages:		***15193.4***	***1883.3***	***5.0***	***121.2***	***1757.1***	***4.7***	***1121.6***	***1126.2***	***2456.2***	***4821.0***	***833.1***	***10793.6***	***71.1***
356	12-Feb-00													
357	13-Feb-00													
358	14-Feb-00	12273.3	1655.0	3.9	290.8	1360.3	3.3	1470.6	1473.9	1911.7	4754.9	694.9	10195.7	83.1
359	15-Feb-00	11948.2	1805.8	-59.1	439.6	1425.3	31.7	2157.2	2188.9	2321.4	4795.5	731.5	11462.6	95.9
360	16-Feb-00	13817.6	1757.8	0.0	337.7	1420.1	13.3	1868.5	1881.8	2184.8	4551.7	877.8	10916.2	79.0
361	17-Feb-00	16465.9	1851.8	0.0	305.3	1546.5	2.0	2405.7	2407.6	3715.9	4341.8	737.3	12749.1	77.4
362	18-Feb-00													
363	19-Feb-00													
364	20-Feb-00	14991.4	1986.2	2.0	399.8	1584.5	3.5	2236.8	2240.3	2614.9	4792.3	774.1	12006.1	80.1
365	21-Feb-00	15810.6	2025.6	1.3	157.0	1867.4	9.8	1287.3	1297.1	3303.0	5242.9	737.3	12447.7	78.7
366	22-Feb-00	14745.6	2121.6	3.4	138.9	1979.4	45.5	1627.6	1673.1	3303.0	5406.7	737.3	13099.5	88.8
367	23-Feb-00	14991.4	1985.3	11.3	122.4	1851.5	14.7	1613.8	1628.5	3853.5	5120.0	847.9	13301.4	88.7
368	24-Feb-00	12533.8	2041.0	-15.9	134.0	1922.9	21.9	1649.0	1670.9	3578.3	5652.5	847.9	13672.4	109.1
BATCH 26 Averages:		***14175.3***	***1914.5***	***-5.9***	***258.4***	***1862.0***	***16.2***	***1812.9***	***1829.1***	***2976.3***	***4962.0***	***776.2***	***12205.8***	***88.8***
369	25-Feb-00													
370	26-Feb-00													
371	27-Feb-00	14417.9	1635.8	5.9	110.8	1519.2	43.5	866.4	909.8	2339.6	4751.4	1032.2	10552.2	73.2
372	28-Feb-00	11714.6	1692.5	-31.9	95.6	1628.8	21.3	1795.6	1816.9	2339.6	4833.3	884.7	11503.3	98.2
373	29-Feb-00	14909.4	1732.8	-72.1	114.3	1690.5	43.5	1628.9	1672.4	2890.1	6103.0	774.1	13130.3	88.1
374	01-Mar-00	13107.2	1572.5	-43.7	120.8	1495.4	24.3	1694.8	1719.1	2339.6	4874.2	921.6	11349.9	86.6
375	02-Mar-00	15122.9	1399.7	-26.3	106.8	1319.2	14.5	1830.9	1845.4	2711.9	5564.9	726.4	12167.8	80.5
376	03-Mar-00													
377	04-Mar-00													
378	05-Mar-00	15122.9	1348.8	-18.2	99.8	1267.2	17.9	1853.5	1871.5	2569.2	6202.1	917.6	12627.5	84.8
379	06-Mar-00	15462.7	1385.3	-34.7	143.4	1276.6	18.3	1693.0	1711.3	3140.1	6074.6	802.9	13005.6	84.1
380	07-Mar-00	13933.4	1585.0	-157.6	168.6	1574.0	80.5	1835.0	1915.5	2711.9	5055.1	955.8	12212.3	87.6
381	08-Mar-00													
382	09-Mar-00													
BATCH 27 Averages:		***14223.9***	***1544.0***	***-47.3***	***120.0***	***1471.4***	***33.0***	***1649.8***	***1682.7***	***2630.3***	***5432.3***	***876.9***	***12093.6***	***85.4***
383	10-Mar-00													
384	11-Mar-00													
385	12-Mar-00	13707.4	1496.6	-131.4	425.7	1202.3	139.2	3045.1	3184.3	2219.4	4145.0	997.3	11748.3	85.7
386	13-Mar-00	14774.4	1827.8	-164.7	605.5	1387.1	117.4	2740.8	2858.2	3051.7	5089.0	738.7	13124.7	88.8
387	14-Mar-00	14856.5	1713.6	-181.9	587.3	1308.2	144.1	2431.5	2575.6	2080.7	5540.4	1255.8	12760.8	85.9
388	15-Mar-00	15513.1	1506.2	-74.5	141.1	1439.7	135.9	2808.2	2944.1	2427.5	4801.7	923.4	12536.3	80.8
389	16-Mar-00	13871.5	1471.7	-181.9	-109.5	1763.1	178.1	2822.8	3001.0	1508.0	4664.4	766.6	11703.1	84.4
390	17-Mar-00													
391	18-Mar-00													
392	19-Mar-00	14358.2	1769.3	-225.8	555.1	1439.9	154.1	2664.1	2818.2	2330.6	5394.5	766.6	12749.7	88.8
393	20-Mar-00	14033.8	1878.7	-73.6	503.9	1448.5	70.7	2496.6	2567.3	2467.7	5070.0	839.6	12393.1	88.3

Day No.	Date	COD In mgCOD/d	MOT Consumed mgO/d	O Demand NO2 mgO/d	O Demand NO3 mgO/d	MOC mgO/d	COD used NO2 Denit. mgCOD/d	COD used NO3 Denit. mgCOD/d	COD used Tot. Denit. mgCOD/d	COD used Nitrifier mgCOD/d	COD in Waste mgCOD/d	COD in Effluent mgCOD/d	Total COD out mgCOD/d	% Recovery mgCOD/d
394	21-Mar-00	16386.2	1916.2	-21.3	594.1	1343.4	36.2	2839.0	2875.2	2741.9	4867.2	876.1	12703.7	77.5
395	22-Mar-00	14638.7	1771.2	-25.2	626.6	1169.8	26.2	2652.3	2678.4	2362.8	4934.4	962.2	12107.6	82.7
396	23-Mar-00													
397	24-Mar-00													
BATCH 28 Averages:		***14682.2***	***1705.7***	***-120.0***	***436.6***	***1389.1***	***111.3***	***2722.3***	***2833.6***	***2354.5***	***4945.2***	***902.9***	***12425.3***	***84.8***
398	25-Mar-00													
399	26-Mar-00	13734.1	1707.8	0.0	312.1	1395.7	3.0	2197.5	2200.5	2084.8	4893.3	851.2	11425.5	83.2
400	27-Mar-00	14803.2	1735.7	13.0	242.3	1480.4	20.2	1594.0	1614.2	2501.7	4194.2	962.2	10752.9	72.6
401	28-Mar-00	14524.8	1746.2	15.7	391.0	1339.5	6.7	1707.9	1714.6	3447.6	4284.0	771.1	11556.9	79.6
402	29-Mar-00	15096.0	1688.6	-3.9	232.7	1459.9	7.4	1774.0	1781.4	3447.6	4243.2	881.3	11813.4	78.3
403	30-Mar-00	15504.0	1830.7	14.5	218.3	1597.9	7.2	1795.4	1802.5	2206.5	4406.4	734.4	10747.7	69.3
404	31-Mar-00													
405	01-Apr-00													
406	02-Apr-00	15340.8	1680.0	23.9	161.3	1494.8	30.2	1849.9	1880.1	2620.2	4651.2	1175.0	11821.3	77.1
407	03-Apr-00	14336.0	2027.5	7.9	198.1	1821.5	7.1	1537.9	1545.0	2353.6	4587.5	1032.2	11339.8	79.1
BATCH 29 Averages:		***14762.7***	***1773.8***	***10.2***	***250.8***	***1512.8***	***11.7***	***1779.5***	***1791.2***	***2666.0***	***4465.7***	***915.3***	***11351.1***	***77.0***
408	04-Apr-00													
409	05-Apr-00													
410	06-Apr-00	14827.5	2279.0	11.8	519.5	1747.7	12.6	2077.2	2089.9	2076.7	4792.3	1069.1	11775.6	79.4
411	07-Apr-00													
412	08-Apr-00													
413	09-Apr-00	14909.4	2066.9	17.7	499.9	1549.3	11.6	2042.7	2054.3	1661.3	4505.6	811.0	10581.5	71.0
414	10-Apr-00	15319.0	2071.7	5.9	499.9	1565.9	17.5	2197.5	2215.0	1522.9	4628.5	995.3	10927.7	71.3
415	11-Apr-00	14581.8	1755.8	-47.4	337.2	1466.0	30.2	1839.2	1869.4	992.1	4423.7	958.5	9709.7	66.6
416	12-Apr-00	15073.3	1691.5	-47.4	262.5	1476.5	31.0	2052.0	2083.0	1984.1	4587.5	958.5	11089.5	73.6
417	13-Apr-00	15155.2	1645.4	-49.4	269.3	1425.6	30.4	2215.0	2245.3	1700.7	4259.8	1105.9	10737.3	70.8
418	14-Apr-00													
419	15-Apr-00													
420	16-Apr-00	14827.5	1522.6	-55.3	165.1	1412.8	33.0	2249.5	2282.5	1558.9	3973.1	1142.8	10370.2	69.9
421	17-Apr-00													
BATCH 30 Averages:		***14956.3***	***1861.9***	***-23.5***	***364.8***	***1520.6***	***23.7***	***2096.2***	***2119.9***	***1842.4***	***4452.9***	***1005.9***	***10741.6***	***71.8***
422	18-Apr-00													
423	19-Apr-00													
424	20-Apr-00													
425	21-Apr-00													
426	22-Apr-00													
427	23-Apr-00													
428	24-Apr-00	19552.0	2020.8	0.0	124.7	1896.1	0.0	2005.2	2005.2	1091.3	4472.0	1778.4	11242.9	57.5
429	25-Apr-00	18512.0	1874.9	0.0	124.7	1750.1	0.0	2103.8	2103.8	3273.8	6032.0	1404.0	14563.7	78.7
430	26-Apr-00	18304.0	1830.7	0.0	-10.8	1841.6	0.0	2081.3	2081.3	4183.1	6708.0	1544.4	16358.4	89.4
431	27-Apr-00	18408.0	1850.9	0.0	10.8	1840.0	0.0	2304.3	2304.3	3273.8	6500.0	1263.6	15181.7	82.5
432	28-Apr-00	18720.0	2046.7	0.0	75.9	1970.8	0.0	2394.2	2394.2	2182.5	6968.0	1310.4	14825.9	79.2
433	29-Apr-00													
434	30-Apr-00	17170.0	1932.5	0.0	227.8	1704.7	0.0	2282.0	2282.0	3709.2	5959.0	1363.5	15018.4	87.5
435	01-May-00	17776.0	1868.2	0.0	121.5	1746.7	5.5	2057.4	2062.9	3355.9	5757.0	1181.7	14104.2	79.3
436	02-May-00	17574.0	1727.0	-14.7	140.0	1601.7	8.2	2166.8	2175.0	4415.7	5757.0	1363.5	15312.9	87.1
437	03-May-00	18281.0	1918.1	-14.2	185.8	1746.5	9.5	2065.4	2074.9	3885.8	5858.0	1181.7	14746.9	80.7
438	04-May-00	18600.0	2062.1	0.5	212.7	1848.9	3.2	2252.3	2255.6	3847.4	5800.0	1440.0	15191.8	81.7
BATCH 31 Averages:		***18289.7***	***1913.2***	***-2.8***	***121.3***	***1794.7***	***2.6***	***2171.3***	***2173.9***	***3321.8***	***5981.1***	***1383.1***	***14854.7***	***80.4***
439	05-May-00													
440	06-May-00													
441	07-May-00													
442	08-May-00	18900.0	2573.8	22.8	309.8	2241.2	8.9	2834.3	2843.2	2623.2	6100.0	1710.0	15517.6	62.1
443	09-May-00	19500.0	2441.3	-163.5	500.1	2124.7	143.9	2185.6	2329.5	3070.1	5950.0	1305.0	14779.3	75.8
444	10-May-00	18900.0	2546.9	-44.6	501.4	2090.2	29.8	2624.0	2653.9	3070.1	6000.0	1260.0	15074.1	79.8
445	11-May-00	19500.0	2679.4	-44.6	506.7	2217.3	29.4	2787.3	2816.7	2558.4	6000.0	1260.0	14852.5	76.2
446	12-May-00	19400.0	2621.8	0.0	425.9	2195.9	13.6	2894.7	2908.3	2046.7	7250.0	1305.0	15705.9	81.0
447	13-May-00													
448	14-May-00	19300.0	2566.1	2.5	566.3	1997.3	6.4	3149.7	3156.0	1876.2	6600.0	1350.0	14979.5	77.6
449	15-May-00	18800.0	2354.9	-133.9	476.6	2012.2	86.9	2906.1	2993.0	2046.7	5900.0	1170.0	14121.9	75.1
450	16-May-00													
451	17-May-00	23469.6	1947.8	-188.2	505.7	1630.3	100.9	3103.2	3204.1	1213.0	6400.8	1554.5	14002.7	59.7
452	18-May-00	18186.4	2435.5	-151.0	488.7	2097.9	93.8	2930.2	3024.0	1386.3	6096.0	1371.6	13975.8	76.8
453	19-May-00													
454	20-May-00													
455	21-May-00	18999.2	2323.2	-94.1	482.3	1935.0	74.1	3618.3	3692.4	2945.9	7823.2	1828.8	18225.3	95.9
456	22-May-00													
BATCH 32 Averages:		***19495.5***	***2449.1***	***-81.5***	***476.3***	***2054.2***	***58.8***	***2903.3***	***2962.1***	***2283.7***	***6412.0***	***1411.5***	***15123.5***	***78.0***
457	23-May-00													
458	24-May-00													
459	25-May-00													
460	26-May-00													
461	27-May-00													
462	28-May-00													
463	29-May-00													
464	30-May-00													
465	31-May-00													
466	01-Jun-00													
467	02-Jun-00													
468	03-Jun-00													
469	04-Jun-00													
470	05-Jun-00													
BATCH 33 Averages:														
471	06-Jun-00													

[redacted]		COD	MOT	O Demand	O Demand	MOC	COD used	COD used	COD used	COD used	COD in	COD in	Total COD	%
		In	Consumed	NO2	NO3		NO2 Denit.	NO3 Denit.	Tot. Denit.	Nitrifier	Waste	Effluent	out	Recovery
Day No.	Date	mgCOD/d	mgO/d	mgO/d	mgO/d	mgO/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d
472	07-Jun-00													
473	08-Jun-00													
474	09-Jun-00													
475	10-Jun-00													
476	11-Jun-00	17871.2	1280.6	133.8	361.9	785.0	70.0	2518.6	2588.6	2397.4	8674.6	1686.7	16132.3	90.3
477	12-Jun-00	16566.0	1911.4	118.9	310.6	1481.8	52.5	2891.6	2944.1	2568.6	7871.4	1518.0	16384.0	98.9
478	13-Jun-00	17670.4	2043.8	94.2	244.1	1705.6	38.5	3277.4	3315.9	2739.9	7228.8	1939.7	16929.8	95.8
479	14-Jun-00	18574.0	1819.2	118.9	310.6	1389.7	59.5	2951.5	3011.0	3082.4	6666.6	1981.9	16131.5	86.8
480	15-Jun-00	19051.2	1711.7	168.5	88.2	1455.0	86.3	3438.9	3525.1	3610.4	7015.7	1989.8	17596.0	92.4
481	16-Jun-00	16632.0	1503.4	198.2	-221.5	1526.6	79.6	3497.8	3577.5	3266.6	6289.9	1862.8	16523.3	99.3
482	17-Jun-00													
483	18-Jun-00	17740.8	1648.3	203.2	440.0	1005.1	84.7	3522.8	3607.5	3266.6	4838.4	1354.8	14072.4	79.3
BATCH 34 Averages:		***17729.4***	***1702.6***	***148.0***	***219.1***	***1335.5***	***67.3***	***3156.9***	***3224.2***	***2990.3***	***6940.8***	***1762.0***	***16252.7***	***91.8***

APPENDIX C

- **Biological Excess P Removal Steady State Model by Wentzel *et al.* (1990)**

- **Method of Determining $f_{s,up}$ and $f_{xbg,p}$**

THE STEADY STATE BEPR MODEL BY WENTZEL *et al.* (1990)

- Readily biodegradable COD available for conversion to short chain fatty acids (SCFA):

$S'_{bsi} = S_{bsi}$ - r(8.6)(NO_3 recycled) - r(5.0)(NO_2 recycled)   (NO_3 and NO_3 in mgN/l)

- RBCOD not converted:

→ Assume S_{bsN} = 0 mgCOD/l and calculate $\frac{MX_{b,h}}{Q}$ from

$$\frac{MX_{b,h}}{Q} = \frac{[S_{bi} - (S'_{bsi} - (1+r)S_{bsN})]Y_H R_S}{(1+b_H R_s)}$$

→ Using the calculated value for $\frac{MX_{b,h}}{Q}$, calculate S_{bsN} from

$$S_{bsN} = \frac{\frac{S'_{bsi}}{(1+r)}}{[1 + K\frac{\frac{f_{xa}MX_{b,h}}{Q}}{(1+r)}]}$$

→ Repeat until S_{bsN} and $\frac{MX_{b,h}}{Q}$ are constant, and when this is true, the required S_{bsN} value has been found.

- SCFA sequestered by the PAOs per day:

$MS_{seq} = [S'_{bsi} - (1+r)S_{bsN}]Q$

- P release by the PAOs per day:

$MP_{rel} = 0.5(MS_{seq})$

- Substrate available to OHOs per day:

$MS_{b,h} = QS_{bi} - MS_{seq}$

- PAOs:

→ Biological active mass

$$MX_{b,g} = \frac{Y_G MS_{seq} R_s}{1 + b_G R_s}$$

→ Endogenous mass

$MX_{e,g} = f_{epg} b_G MX_{b,g} R_s$

→ P removal for PAOs per day

$$\Delta P_G = f_{xbg,p} \frac{MX_{b,g}}{R_s} + f_{xeg,p} \frac{MX_{e,g}}{R_s}$$

- OHOs:

→ Biological active mass

$$MX_{b,h} = \frac{Y_H MS_{b,h} R_s}{(1 + b_H R_s)}$$

→ Endogenous mass

$MX_{e,h} = f_{ep,h} b_H MX_{b,h} R_s$

→ P removal for OHOs per day

$$\Delta P_H = f_{xbh,p} \frac{MX_{b,h}}{R_s} + f_{xeh,p} \frac{MX_{e,h}}{R_s}$$

- Inert mass:

$$MX_i = f_{s,up} Q S_{ti} R_s / f_{cv}$$

→ P removal for inert mass per day

$$\Delta P_i = f_{xi,p} \frac{MX_i}{R_s}$$

- Total system P removal per day:

$$\Delta P = \Delta P_G + \Delta P_H + \Delta P_i$$

where:

r	= Recycle ratio to anaerobic rector with respect to influent flow.
Q	= System influent flow in l/d.
R_s	= System sludge age in days.
f_{xa}	= System anaerobic mass fraction.
S_{bsi}	= Influent RBCOD concentration in mgCOD/l.
S'_{bsi}	= RBCOD available for conversion in mgCOD/l.
S_{bsN}	= RBCOD not converted in mgCOD/l.
S_{bi}	= Influent biodegradable COD concentration in mgCOD/l.
S_{ti}	= Total influent COD concentration in mgCOD/l.
MS_{seq}	= Mass of SCFA sequestered by PAOs in mgCOD/d.
$MS_{b,h}$	= Mass of substrate available for OHOs in mgCOD/d.
Y_H	= Heterotrophic organism yield in mgVASS/mgCOD.
b_H	= Heterotrophic endogenous mass loss rate constant in mgVASS/mgVASS.d
Y_G	= Specific yield constant for PAOs in mgVASS/mgCOD.
b_G	= Specific endogenous mass loss rate constant for PAOs in mgVASS/mgVASS.d
K	= First order rate constant.
$f_{s,up}$	= Unbiodegradable particulate fraction of influent COD.
f_{cv}	= COD/VSS ratio of the volatile solids.
$MX_{b,g}$	= PAO active mass in mgVASS.
$MX_{e,g}$	= PAO endogenous mass in mgVESS.

$MX_{b,h}$	= OHO active mass in mgVASS.
$MX_{e,h}$	= OHO endogenous mass in mgVESS.
MX_i	= Inert mass in mgVISS.
f_{epg}	= Fraction of PAOs that is unbiodegradable particulate residue in mgVSS/mgVASS.
$f_{xbg,p}$	= Fractional P content of PAO active mass in mgP/mgVASS.
$f_{xeg,p}$	= Fractional P content of PAO endogenous mass in mgP/mgVESS.
$f_{ep,h}$	= Fraction of OHOs that is unbiodegradable particulate residue in mgVSS/mgVASS.
$f_{xbh,p}$	= Fractional P content of OHO active mass in mgP/mgVASS.
$f_{xeh,p}$	= Fractional P content of OHO endogenous mass in mgP/mgVESS.
$f_{xi,p}$	= Fractional P content of inert mass in mgP/mgVISS.
ΔP_G	= P removal by PAOs in mgP/d.
ΔP_H	= P removal by OHOs in mgP/d.
ΔP_i	= P removal by inert mass in mgP/d.
ΔP	= Total P removal.

METHOD USED TO DETERMINE $f_{s,up}$ AND $f_{xbg,p}$

The approach used to calculate the unbiodegradable particulate COD mass fraction ($f_{s,up}$) and the P content of the PAOs ($f_{xbg,p}$) follows the steady state BEPR model of Wentzel *et al.* (1990). The formulas for the steady state BEPR model are given above, and a schematic representation is given in Table C1 below. The model is structured such that the heterotrophic organism mass is divided into two groups; the OHOs and the PAOs. Each group has its own unique stoichiometric and kinetic constants, and the P content of the PAOs is much larger that of the OHOs. With the total influent COD (S_{ti}), the influent RBCOD (S_{bsi}) and the influent unbiodegradable soluble COD fraction ($f_{s,us}$ = filtered effluent COD / total influent COD) known, an estimate of the $f_{s,up}$ is made and then the biodegradable COD (S_{bi}) is calculated ($S_{bi} = S_{ti} - [(f_{s,us} + f_{s,up})S_{ti}]$). The split of the biodegradable COD between the PAOs and the OHOs and hence the active and endogenous masses for the PAOs and OHOs as well as the inert mass is calculated from the steady state BEPR model of Wentzel *et al.* (1990). By adding the calculated values for the active and endogenous masses for the OHOs and the PAOs as well as the inert mass, the total calculated VSS is obtained.

TABLE C1 - Diagrammatic representation of the approach used to calculate $f_{s,up}$ and $f_{xbg,p}$ following the utilisation of the total influent COD as per the steady state BEPR model of Wentzel *et al.* (1990).

<table>
<tr><td colspan="6">TOTAL COD (S_{ti}) - KNOWN</td></tr>
<tr><td colspan="4">Total Biodegradable COD (S_b) - UNKNOWN</td><td colspan="2">Total Unbiodegradable COD (S_u) - UNKNOWN</td></tr>
<tr><td colspan="2">RBCOD (S_{bs}) - KNOWN</td><td colspan="2">SBCOD (S_{bp}) - UNKNOWN</td><td>$f_{s,up}$ - UNKNOWN [1]</td><td>$f_{s,us}$ - KNOWN</td></tr>
<tr><td colspan="2">COD Obtained by PAOs</td><td colspan="2">COD Obtained by OHOs</td><td>Unbiodegradable Particulate COD - UNKNOWN</td><td>Unbiodegradable Soluble COD - KNOWN</td></tr>
<tr><td>PAO Active Mass</td><td>PAO Endogenous Mass</td><td>OHO Active Mass</td><td>OHO Endogenous Mass</td><td>Inert Mass</td><td>-</td></tr>
<tr><td colspan="5">P Content of VSS Constituents</td><td>-</td></tr>
<tr><td>$f_{xbg,p}$ [2]</td><td>$f_{xeg,p} = 0.03$</td><td>$f_{xbh,p} = 0.03$</td><td>$f_{xeh,p} = 0.03$</td><td>$f_{xi,p} = 0.03$</td><td>-</td></tr>
<tr><td colspan="2">ΔP_G</td><td colspan="2">ΔP_H</td><td>ΔP_I</td><td>-</td></tr>
<tr><td colspan="5">ΔP</td><td>-</td></tr>
</table>

[1] Varied until calculated VSS (by steady state BEPR model) equals the VSS measured in the ENBNRAS system.
[2] Varied until calculated P removal (by steady state BEPR model) equalsP removal measured in ENBNRAS system.

By an iterative process the $f_{s,up}$ is varied until the calculated VSS equals the VSS measured in the ENBNRAS system. Once the two VSS masses are equal, the correct $f_{s,up}$ value has been obtained. Once the $f_{s,up}$ value has been established, an estimation is made for the $f_{xbg,p}$ and the theoretical P removal is calculated by the steady state BEPR model of Wentzel *et al.* (1990). By an iterative process the $f_{xbg,p}$ value is varied until the calculated P removal is equal the P removal measured in the ENBNRAS system. Once the two P removals are equal, the correct $f_{xbg,p}$ value has been established.

The calculations in Chapter 3 Section 3.3.3.4 were done for two different scenarios, (i) taking into account the COD consumed in the EN system only and (ii) taking account of the COD consumed in the EN system and the COD unaccounted for in the COD mass balances. The COD was corrected for (i) by reducing the biodegradable particulate COD (leaving the RBCOD and the unbiodegradable COD unchanged) by the concentration of COD that was utilised in the EN system and for (ii) by reducing the biodegradable particulate COD (leaving the RBCOD and the unbiodegradable COD unchanged) by the COD concentration that was utilised in the EN system and by the COD concentration that was unaccounted for in the COD mass balances.

APPENDIX D

- **Filamentous Organism Identifications**

Date of Filamentous Organism Identification	18 January 1999
System / System Reactor	ENBNRAS / Main Aerobic
Overall Filament Abundance	Common
Morphology of Floc	Firm, Round and Compact
Floc Diameter (μm)	150 - 500

Filament	Rank	Abundance
M.parvicella	1	Common
type 1851	2	Few
Thiothrix	3	Few

Comments	Paramecium, ASPA DISCA cosata, Trachelophylum, no stalked ciliates. Sludge worms.

Date of Filamentous Organism Identification	22 February 1999
System / System Reactor	ENBNRAS / Main Aerobic
Overall Filament Abundance	Common
Morphology of Floc	Weak, Somewhat Rounded
Floc Diameter (μm)	150 - 500

Filament	Rank	Abundance
type 1851	1	Common
M.parvicella	2	Some

Comments	ASPA DISCA costata, Vorticella convulluria, Protozoans.

Date of Filamentous Organism Identification	24 March 1999
System / System Reactor	ENBNRAS / Main Aerobic
Overall Filament Abundance	Some
Morphology of Floc	Irregular, Diffuse
Floc Diameter (μm)	< 150

Filament	Rank	Abundance
type 1851	1	Some
M.parvicella	2	Few

Comments	Protozoans.

Date of Filamentous Organism Identification	28 April 1999	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Common	
Morphology of Floc	Firm, Irregular, Diffuse	
Floc Diameter (μm)	150 - 500	
Filament	**Rank**	**Abundance**
type 1851	1	Some
M.parvicella	2	Some
type 1701	3	Few
Comments	Stalked Ciliates, Floc tends to string out.	

Date of Filamentous Organism Identification	27 May 1999	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Some	
Morphology of Floc	Weak, Irregular and Diffuse	
Floc Diameter (μm)	< 150	
Filament	**Rank**	**Abundance**
M.parvicella	1	Some
type 0092	2	Few
Comments	Protozoans, Paramecium, ASPA DISCA costata.	

Date of Filamentous Organism Identification	22 June 1999	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Common	
Morphology of Floc	Firm, Irregular, Diffuse	
Floc Diameter (μm)	150 - 500	
Filament	**Rank**	**Abundance**
M.parvicella	1	Common
type 1851	2	Some
Thiothrix	3	Few
Norcardia	4	Few
Comments	Stalked Ciliates, Crawling Ciliates, ASPA DISCA. Best Floc of Samples Examined.	

Date of Filamentous Organism Identification	28 July 1999	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Some	
Morphology of Floc		
Floc Diameter (μm)		
Filament	**Rank**	**Abundance**
type 1851	1	Some
M.parvicella	2	Few
type 0041	3	Few
Comments	A Few ASPA DISCA Present.	

Date of Filamentous Organism Identification	26 August 1999	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Some	
Morphology of Floc	Weak, Irregular and Diffuse	
Floc Diameter (μm)	150 - 500	
Filament	**Rank**	**Abundance**
M.parvicella	1	Some
H.hydrossis	2	Few
Comments	Very Little Solids.	

Date of Filamentous Organism Identification	29 September 1999	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Some	
Morphology of Floc	Firm, Irregular, Diffuse	
Floc Diameter (μm)	150 - 500	
Filament	**Rank**	**Abundance**
type 1851	1	Some
H.hydrossis	2	Few
Comments	Not Much Visible Activity.	

Date of Filamentous Organism Identification	25 October 1999
System / System Reactor	ENBNRAS / Main Aerobic
Overall Filament Abundance	Some
Morphology of Floc	Weak, Irregular and Diffuse
Floc Diameter (µm)	150 - 500

Filament	Rank	Abundance
type 1851	1	Some

Comments	Solids Seem a Bit Low, Not Much Activity.

Date of Filamentous Organism Identification	22 November 1999
System / System Reactor	ENBNRAS / Main Aerobic
Overall Filament Abundance	Common
Morphology of Floc	
Floc Diameter (µm)	< 150

Filament	Rank	Abundance
type 1851	1	Common
M.parvicella	2	Few

Comments	Small Floc Size, Low Activiy.

Date of Filamentous Organism Identification	20 December 1999
System / System Reactor	ENBNRAS / Main Aerobic
Overall Filament Abundance	Common
Morphology of Floc	Weak, Irregular and Diffuse
Floc Diameter (µm)	< 150

Filament	Rank	Abundance
type 1851	1	Common
M.parvicella	2	Few

Comments	Solids Seem Low, Floc Weak, Not Much Activity.

Date of Filamentous Organism Identification	19 January 2000	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Very Common	
Morphology of Floc	Weak, Irregular and Diffuse	
Floc Diameter (μm)	< 150	
Filament	**Rank**	**Abundance**
M.parvicella	1	Very Common
type 1851	2	Common
Comments	Floc Very Weak.	

Date of Filamentous Organism Identification	20 February 2000	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Very Common	
Morphology of Floc	Weak, Irregular and Diffuse	
Floc Diameter (μm)	150 - 500	
Filament	**Rank**	**Abundance**
M.parvicella	1	Common
type 1851	2	Some
Comments	Weak Floc.	

Date of Filamentous Organism Identification	23 March 2000	
System / System Reactor	ENBNRAS / Main Aerobic	
Overall Filament Abundance	Very Common	
Morphology of Floc	Very Common	
Floc Diameter (μm)	150 - 500	
Filament	**Rank**	**Abundance**
M.parvicella	1	Very Common
type 1851	2	Some
type 0092	3	Some
Comments	ASPA DISCA costata.	

Date of Filamentous Organism Identification		24 April 2000
System / System Reactor		ENBNRAS / Main Aerobic
Overall Filament Abundance		Abundant
Morphology of Floc		Weak, Irregular and Diffuse
Floc Diameter (μm)		150 - 500
Filament	**Rank**	**Abundance**
M.parvicella	1	Abundant
type 0092	2	Few
Comments		

Date of Filamentous Organism Identification		23 May 2000
System / System Reactor		ENBNRAS / Main Aerobic
Overall Filament Abundance		Abundant
Morphology of Floc		Weak, Irregular and Diffuse
Floc Diameter (μm)		< 150
Filament	**Rank**	**Abundance**
M.parvicella	1	Very Common
type 0092	2	Some
Comments		It Is Surprising That The Sludge Settles So Well, The Floc Is Weak And It Has A High Number Of Filaments.

Date of Filamentous Organism Identification		22 June 2000
System / System Reactor		ENBNRAS / Main Aerobic
Overall Filament Abundance		Very Common
Morphology of Floc		Weak, Irregular and Diffuse
Floc Diameter (μm)		< 150
Filament	**Rank**	**Abundance**
M.parvicella	1	Very Common
type 1851	2	Some
Comments		Large Numbers Of ASPA DISCA - This Often Indicates A Sudden Rise In Bacterial Activity.

APPENDIX E

- **Daily Results of the UCT System for the Period it was Run in Parallel with the ENBNRAS System (Sewage Batches 13 to 30)**

TABLE E1 - Abbreviations used in tables.

I	Influent
ML	Mixed Liquor
An	Anaerobic Reactor
Ax	Anoxic Reactor
Aero	Aerobic Reactor
SET or ST	Final Settling Tank
UE	Unfiltered Effluent
FE	Filtered Effluent

	Date	Day	COD (mgCOD/l)				TKN (mg N/l)				FSA (mg N/l)			TKN/
			I	ML	UE	FE	I	ML	UE	FE	I	UE	FE	COD
Batch 1/13	Sat 07/08	167												
	Sun 08/08	168												
	Mon 09/08	169												
	Tues 10/08	170	774.1	2498.6	65.5	57.3	89.6	100.8	0.0	0.0	65.0	0.0	0.0	0.116
	Wed 11/08	171	950.3	2662.4	127.0	32.8	76.2	161.0	1.7	1.3	55.4	0.0	0.0	0.080
	Thur12/08	172	766.0	1884.2	49.2	45.1	70.0	0.0	0.6	0.0	62.4	0.0	0.0	0.091
	Frid 13/08	173												
	Sat 14/08	174	733.2	2908.2	90.1	61.4	79.0	194.6	8.3	8.7	54.6	10.5	4.5	0.108
	Sun 15/08	175	703.1	2841.2	63.4	34.7	81.5	329.0	8.3	5.9	48.7	5.6	5.5	0.116
	Mon 16/08	176	690.9	2820.7	45.0	40.9	79.0	154.0	3.8	2.9	67.8	2.8	1.1	0.114
	Tues 17/08	177	846.2	2759.4	57.2	28.6	84.6	145.6	0.8	0.0	67.8	0.0	0.0	0.100
	Wed 18/08	178	817.6	2739.0	61.3	49.1	79.2	148.4	0.0	0.0	64.4	0.0	0.0	0.097
	Thur 19/08	179	854.4	2943.4	81.8	49.1	87.9	137.2	0.3	0.0	70.0	0.4	0.0	0.103
	Frid 20/08	180	764.5	2677.6	63.4	47.0	84.6	140.0	2.2	2.0	49.3	0.4	0.0	0.111
	Sat 21/08	181												
	Sun 22/08	182												
	Mon 23/08	183	799.3	2430.8	37.1	28.8	91.3	144.2	3.2	2.2	69.4	1.4	1.3	0.114
	Tues 24/08	184												
	Wed 25/08	185												
	Thur 26/08	186												
AVERAGE	***Batch 1/13***		***790.9***	***2651.4***	***67.4***	***43.2***	***82.1***	***150.4***	***2.6***	***2.1***	***61.3***	***1.9***	***1.1***	***0.104***
Batch 2 /14	Frid 27/08	187												
	Sat 28/08	188												
	Sun 29/08	189	671.6	2636.8	65.9	49.2	81.5	0.0	0.0	2.5	52.1	0.8	0.6	0.121
	Mon 30/08	190	700.4	1318.4	47.4	30.9	72.8	0.0	3.9	1.7	58.8	3.1	1.7	0.104
	Tues 31/08	191												
	Wed 01/09	192												
	Thur 02/09	193												
	Frid 03/09	194												
	Sat 04/09	195												
	Sun 05/09	196												
	Mon 06/09	197	714.1	2790.7	53.4	28.7	77.0	175.0	2.2	0.3	55.2	0.3	0.1	0.108
	Tues 07/09	198	681.3	2421.4	57.5	45.1	61.3	151.2	3.4	3.4	57.1	1.5	1.4	0.090
	Wed 08/09	199	697.7	2339.3	82.1	39.0	79.4	138.6	2.5	0.0	51.2	1.4	1.5	0.114
	Thur 09/09	200	648.4	2154.6	39.0	32.8	56.0	145.6	4.2	0.0	42.0	1.1	0.8	0.086
	Frid 10/09	201												
	Sat 11/09	202												
	Sun 12/09	203												
AVERAGE	***Batch 2/14***		***685.6***	***2732.2***	***57.5***	***37.6***	***71.3***	***101.7***	***2.7***	***1.3***	***52.7***	***1.4***	***1.0***	***0.104***
Batch 3/15	Mon 13/09	204												
	Tues 14/09	205												
	Wed 15/09	206												
	Thur 16/09	207	686.8	1492.1	67.5	55.2	85.4	92.4	7.0	2.2	67.5	1.1	1.0	0.124
	Frid 17/09	208												
	Sat 18/09	209												
	Sun 19/09	210												
	Mon 20/09	211												
	Tues 21/09	212	793.1	2350.6	47.0	40.9	88.5	159.6	4.9	3.4	72.2	2.8	1.4	0.112
	Wed 22/09	213	689.5	2667.6	51.3	34.9	93.8	229.6	4.2	0.0	69.7	2.1	0.0	0.136
	Thur 23/09	214												
	Frid 24/09	215												
	Sat 25/09	216												
	Sun 26/09	217												
	Mon 27/09	218												
	Tues 28/09	219												
AVERAGE	***Batch 3/15***		***723.1***	***2170.1***	***55.3***	***43.7***	***89.2***	***160.5***	***5.4***	***1.9***	***69.8***	***2.0***	***0.8***	***0.124***
Batch 4/16	Wed 29/09	220	677.2	2113.6	108.8	75.9	91.0	142.8	4.3	0.0	72.8	1.0	0.0	0.134
	Thur 30/09	221	751.0	1990.4	61.6	53.4	78.4	107.8	2.9	2.5	58.2	0.4	0.4	0.104
	Frid 1/10	222												
	Sat 2/10	223												
	Sun 3/10	224	716.8	3010.6	51.2	36.9	76.7	203.0	2.8	2.7	63.0	0.7	0.8	0.107
	Mon 4/10	225												
	Tues 5/10	226	786.4	2805.8	57.3	41.0	86.0	183.4	2.9	0.8	59.4	1.5	0.7	0.109
	Wed 6/10	227	733.2	2828.2	38.9	28.7	85.4	203.0	2.7	0.4	57.7	0.7	0.0	0.116
	Thur 7/10	228	729.1	2826.2	51.2	51.2	80.4	168.0	3.2	2.9	62.4	2.2	1.4	0.110
	Frid 8/10	229												
	Sat 9/10	230												
	Sun 10/10	231												
	Mon 11/10	232												
AVERAGE	***Batch 4/16***		***732.3***	***2595.5***	***61.5***	***47.8***	***83.0***	***168.0***	***3.2***	***1.6***	***62.3***	***1.1***	***0.5***	***0.114***
Batch 5/17	Tues 12/10	233												

	Date	Day	COD (mgCOD/l)				TKN (mg N/l)				FSA (mg N/l)			TKN/
			I	ML	UE	FE	I	ML	UE	FE	I	UE	FE	COD
	Wed 13/10	234	648.0	2468.5	52.9	33.1	66.1	182.0	4.9	0.1	49.1	2.1	0.8	0.102
	Thur 14/10	235	705.3	2512.6	24.2	13.2	65.5	177.8	2.9	2.4	49.6	2.2	1.1	0.093
	Frid 15/10	236												
	Sat 16/10	237												
	Sun 17/10	238	608.3	2226.0	48.5	30.9	62.2	191.8	2.9	2.8	48.2	0.7	0.4	0.102
	Mon 18/10	239												
	Tues 19/10	240	700.9	2556.6	35.3	33.1	61.6	133.0	3.4	2.1	46.8	1.8	1.5	0.088
	Wed 20/10	241	750.7	2611.2	40.8	36.7	60.8	168.0	2.9	1.0	46.5	0.3	0.1	0.081
	Tues 21/10	242	685.4	2529.6	49.0	40.8	61.9	170.8	2.9	2.8	49.8	0.4	0.1	0.090
	Frid 22/10	243												
	Sat 23/10	244												
	Sun 24/10	245	648.7	2692.8	71.4	40.8	66.4	186.2	2.9	2.9	52.4	0.7	0.7	0.102
	Mon 25/10	246	656.9	2346.0	28.6	20.4	65.8	161.0	2.7	0.0	40.3	0.6	0.3	0.100
AVERAGE	***Batch 5/17***		***675.5***	***2492.9***	***43.8***	***31.1***	***63.8***	***171.3***	***3.2***	***1.8***	***47.8***	***1.1***	***0.6***	***0.095***
Batch 6/18	Tues 26/10	247												
	Wed 27/10	248	697.7	2264.4	57.1	34.7	64.1	148.4	3.6	3.4	47.0	0.6	0.3	0.092
	Tues 28/10	249	930.2	2407.2	32.6	32.6	66.6	156.8	2.2	2.1	59.9	0.8	0.3	0.072
	Frid 29/10	250	860.9	2815.2	81.6	46.9	66.9	159.6	4.5	0.6	51.2	0.8	1.4	0.078
	Sat 30/10	251												
	Sun 31/10	252	811.9	2652.0	61.2	53.0	64.7	172.2	2.7	1.5	51.0	1.3	1.1	0.080
	Mon 1/11	253												
	Tues 2/11	254	767.0	2611.2	46.9	28.6	69.2	170.8	3.4	1.3	46.2	0.7	0.4	0.090
	Wed 3/11	255	771.1	2713.2	34.7	36.7	64.7	163.8	3.4	2.8	53.6	0.0	0.4	0.084
	Thur 4/10	256	811.0	2601.0	38.9	32.8	62.2	175.7	2.4	1.0	54.3	0.3	0.4	0.077
	Frid 5/11	257	737.3	2273.3	63.5	57.3	63.3	143.5	2.0	0.7	49.8	0.3	0.3	0.086
	Sat 6/11	258												
	Sun 7/11	259	671.7	2211.8	30.7	24.6	60.8	159.6	2.7	1.4	54.6	0.4	0.3	0.090
	Mon 8/11	260												
AVERAGE	***Batch 6/18***		***784.3***	***2505.5***	***49.7***	***38.6***	***64.7***	***161.2***	***3.0***	***1.6***	***52.0***	***0.6***	***0.5***	***0.083***
Batch 7/19	Tues 9/11	261												
	Wed 10/11	262	688.1	2662.4	61.4	57.3	74.5	162.4	1.4	1.3	61.3	0.3	0.3	0.108
	Thur 11/11	263	856.1	1822.7	38.9	30.7	86.8	121.8	2.5	2.1	63.8	0.3	0.0	0.101
	Frid 12/11	264												
	Sat 13/11	265												
	Sun 14/11	266	576.0	2109.1	32.4	28.4	79.8	165.2	3.8	2.1	63.0	0.3	0.3	0.139
	Mon 15/11	267	799.0	1865.8	28.4	20.3	102.8	165.2	3.6	2.0	80.1	0.3	0.1	0.129
	Tues 16/11	268	778.8	2170.0	60.8	54.8	81.2	151.2	2.2	2.0	71.7	0.3	0.3	0.104
	Wed 17/11	269	835.5	2393.0	44.6	40.6	82.3	163.8	1.8	1.0	69.4	0.6	0.3	0.099
	Thur 18/11	270	795.0	1906.3	48.7	38.5	81.5	196.0	3.1	2.2	66.6	0.4	0.4	0.102
	Frid 19/11	271	981.6	1744.1	56.8	48.7	86.6	128.8	6.3	5.6	69.7	2.1	1.7	0.088
AVERAGE	***Batch 7/19***		***788.7***	***2084.2***	***46.5***	***39.7***	***84.5***	***156.8***	***3.1***	***2.3***	***68.2***	***0.6***	***0.4***	***0.109***
Batch 8/20	Sat 20/11	272												
	Sun 21/11	273	635.5	2088.7	43.4	41.4	68.3	156.8	3.6	2.9	47.6	2.2	2.2	0.082
	Mon 22/11	274												
	Tues 23/11	275	835.5	2460.9	53.8	47.6	84.0	170.8	2.2	2.0	54.0	0.8	0.8	0.101
	Wed 24/11	276	814.8	2254.1	43.4	31.0	71.4	151.2	2.8	2.8	54.0	0.4	0.4	0.088
	Thur 25/11	277	918.2	2150.7	47.6	45.5	82.6	162.4	3.1	3.1	61.0	1.4	1.3	0.090
	Frid 26/11	278	732.1	2088.7	72.4	45.5	62.2	190.4	4.5	3.8	47.6	2.5	2.5	0.085
	Sat 27/11	279												
	Sun 28/11	280	781.7	2750.4	43.4	39.3	68.9	161.0	3.1	2.8	49.6	0.7	0.7	0.088
	Mon 29/11	281												
	Tues 30/11	282	784.9	2514.1	63.4	55.2	63.7	147.0	2.8	2.4	48.2	0.8	1.0	0.081
	Wed 1/12	283	715.4	2330.2	65.4	47.0	62.2	142.8	3.5	2.8	44.2	0.8	0.3	0.087
	Thur 2/12	284	645.9	2248.4	61.3	34.7	58.7	151.9	2.4	2.2	46.2	0.4	0.6	0.091
AVERAGE	***Batch 8/20***		***784.9***	***2320.7***	***54.9***	***43.0***	***69.1***	***159.4***	***3.1***	***2.8***	***50.3***	***1.1***	***1.1***	***0.088***
Batch 9 /21	Frid 3/12	285												
	Sat 4/12	286												
	Sun 5/12	287												
	Mon 6/12	288	695.0	2493.7	53.1	42.9	62.0	197.4	3.9	3.5	47.0	3.6	2.8	0.089
	Tues 7/11	289	695.0	2555.0	85.4	40.9	61.3	180.6	3.9	3.8	51.0	1.5	1.3	0.088
	Wed 8/12	290	739.9	2759.4	45.0	38.8	65.1	191.8	4.3	3.1	51.8	2.5	2.2	0.088
	Thur 9/12	291	690.7	2398.9	37.2	28.9	64.3	187.6	5.2	4.1	55.2	2.9	2.5	0.093
	Frid 10/12	292												
	Sat 11/12	293												
	Sun 12/12	294	886.8	2460.9	53.6	29.0	63.0	186.9	4.6	3.4	48.2	2.9	2.9	0.092
	Mon 13/12	295												
	Tues 14/12	296	785.8	2564.3	76.5	47.6	63.7	156.8	2.9	1.8	46.5	1.4	1.4	0.081
AVERAGE	***Batch 9 /21***		***715.5***	***2538.7***	***55.2***	***37.7***	***63.2***	***183.5***	***4.1***	***3.3***	***49.9***	***2.5***	***2.2***	***0.089***
Batch 10/22	Wed 15/12	297												
	Thur 16/12	298												
	Frid 17/12	299												

	Date	Day	COD (mgCOD/l)				TKN (mg N/l)				FSA (mg N/l)			TKN/
			I	ML	UE	FE	I	ML	UE	FE	I	UE	FE	COD
	Sat 18/12	300												
	Sun 19/12	301	732.1	2460.9	53.8	41.4	77.6	158.2	5.2	4.6	64.7	3.1	2.8	0.106
	Mon 20/12	302	732.1	2502.3	41.4	41.4	77.8	168.0	5.0	4.6	56.0	2.0	2.0	0.106
	Tues 21/12	303	732.1	2419.6	66.2	55.8	77.3	159.6	5.2	4.6	60.5	2.8	2.7	0.106
	Wed 22/12	304	748.6	2336.8	53.8	41.4	79.4	161.7	7.1	7.0	60.8	4.5	3.6	0.106
	Thur 23/12	305	752.8	2357.5	74.4	53.8	76.7	167.3	4.5	4.2	68.9	2.2	2.1	0.102
	Frid 24/12	306												
	Sat 25/12	307												
	Sun 26/12	308	661.8	2605.7	62.0	47.6	77.6	179.9	5.9	5.5	61.3	3.1	2.8	0.117
	Mon 27/12	309												
	Tues 28/12	310												
	Wed 29/12	311	711.4	2398.9	41.4	22.7	77.4	171.5	4.3	4.2	58.2	3.5	3.4	0.109
	Thur 30/12	312	678.3	2212.8	49.6	41.4	74.1	140.0	3.4	3.1	57.1	2.4	2.1	0.109
AVERAGE	***Batch 10/22***		***718.6***	***2411.8***	***55.3***	***43.2***	***77.2***	***163.3***	***5.1***	***4.7***	***60.9***	***2.9***	***2.7***	***0.108***
Batch 11/23	Frid 31/12	313												
	Sat 1/01	314												
	Sun 2/01	315												
	Mon 3/01	316	814.8	2523.0	74.4	64.1	103.6	153.3	7.6	6.6	82.9	5.0	3.2	0.127
	Tues 4/01	317	814.8	2336.8	74.4	45.5	76.0	154.0	6.7	4.9	56.8	2.5	2.2	0.093
	Wed 5/01	318	777.6	2254.1	88.9	45.5	79.5	158.9	8.5	4.6	58.5	3.5	3.2	0.102
	Thur 6/01	319	767.0	2509.2	71.4	53.0	77.8	163.8	6.0	4.5	60.2	3.5	2.8	0.101
	Frid 7/01	320	763.0	2182.8	55.1	38.8	77.3	123.9	5.3	3.6	58.8	3.5	2.9	0.101
	Sat 8/01	321												
	Sun 9/01	322	693.6	2244.0	26.5	24.5	78.7	142.8	5.0	4.5	60.2	3.2	2.9	0.113
	Mon 10/01	323	775.2	2448.0	42.8	28.6	79.5	155.4	2.9	2.8	59.9	1.5	1.3	0.103
	Tues 11/01	324	803.8	2427.6	42.8	38.8	75.7	147.0	2.2	1.8	59.4	1.3	0.8	0.094
	Wed 12/01	325	775.2	2386.8	46.9	24.5	79.1	151.2	4.2	3.5	63.0	0.8	0.7	0.102
	Thur 13/01	326	678.5	2468.4	55.1	34.7	75.3	151.9	5.3	0.0	63.6	2.0	2.1	0.111
	Frid 14/01	327	697.7	2468.4	46.9	38.8	75.9	151.9	3.5	3.1	52.1	2.5	1.5	0.109
AVERAGE	***Batch 11/23***		***760.1***	***2386.3***	***56.9***	***39.7***	***79.9***	***150.4***	***5.2***	***3.8***	***61.4***	***2.7***	***2.2***	***0.105***
Batch 12/24	Sat 15/01	328												
	Sun 16/01	329												
	Mon 17/01	330	563.3	2076.6	12.3	12.3	67.3	139.3	4.5	1.4	53.2	1.8	1.3	0.120
	Tues 18/01	331												
	Wed 19/01	332	764.8	2199.9	59.6	39.1	92.7	140.0	12.0	10.9	75.3	9.1	9.0	0.121
	Thur 20/01	333	727.8	2158.8	39.1	32.9	93.2	144.9	2.9	1.8	67.8	1.5	1.4	0.128
	Frid 21/01	334	657.9	2158.8	45.2	28.8	85.7	152.6	3.5	1.5	70.0	0.8	1.0	0.130
	Sat 22/01	335												
	Sun 23/01	336	814.2	2097.1	49.3	45.2	97.0	131.6	8.1	3.1	79.8	1.5	1.4	0.119
	Mon 24/01	337	719.7	2192.1	43.4	43.4	85.1	147.7	3.4	2.4	68.6	2.2	1.1	0.118
	Tues 25/01	338	752.8	2357.5	41.4	35.2	86.2	151.2	2.7	1.8	70.3	1.3	1.0	0.115
	Wed 28/01	339	748.8	2419.6	51.7	41.4	87.8	149.8	3.1	2.2	66.4	2.0	1.1	0.117
	Thur 27/01	340	740.3	2357.5	41.4	41.4	84.8	153.3	4.1	2.5	63.6	1.4	1.3	0.115
	Frid 28/01	341												
AVERAGE	***Batch 12/24***		***721.1***	***2224.2***	***42.6***	***35.5***	***86.7***	***145.6***	***4.9***	***3.1***	***68.3***	***2.4***	***2.1***	***0.120***
Batch 13/25	Sat 29/01	342												
	Sun 30/01	343	529.4	2440.2	37.2	29.0	42.0	152.6	3.4	2.8	33.3	2.9	1.4	0.079
	Mon 31/01	344	657.6	2564.3	37.2	26.9	53.2	156.8	3.1	2.4	42.8	1.4	1.8	0.081
	Tues 01/02	345	798.2	2440.2	39.3	24.8	65.5	168.7	3.6	3.5	46.2	2.9	1.5	0.082
	Wed 02/02	346	699.0	2502.3	33.1	26.9	60.3	159.6	3.2	2.8	37.0	3.9	2.2	0.086
	Thur 03/02	347												
	Frid 04/02	348												
	Sat 05/02	349	709.9	2468.4	44.9	38.8	58.8	156.1	2.8	2.0	50.7	1.8	0.7	0.083
	Sun 06/02	350	714.0	2488.8	36.7	32.6	62.9	183.1	3.4	2.5	43.7	2.2	2.1	0.088
	Mon 07/02	351	758.9	2631.6	61.2	61.2	59.9	157.5	3.8	3.6	45.1	1.8	1.8	0.079
	Tues 08/02	352	673.2	2550.0	34.7	34.7	59.8	164.5	3.6	3.2	43.4	1.1	0.8	0.089
	Wed 09/02	353	723.4	2540.0	56.9	46.7	59.4	163.8	8.3	4.6	73.6	2.1	2.1	0.082
	Thur 10/02	354	682.8	2479.0	38.6	36.6	59.9	166.8	2.1	1.0	51.0	1.0	1.7	0.088
	Frid 11/02	355												
AVERAGE	***Batch 13/25***		***694.6***	***2510.5***	***42.0***	***35.8***	***58.2***	***160.9***	***3.7***	***2.8***	***46.7***	***2.1***	***1.6***	***0.084***
Batch 14/26	Sat 12/02	356												
	Sun 13/02	357												
	Mon 14/02	358	617.7	2580.6	54.9	46.7	77.0	147.0	3.4	2.4	62.7	2.1	2.1	0.125
	Tues 15/02	359	646.2	2255.5	56.9	50.8	82.5	148.4	3.8	2.7	66.6	1.8	2.1	0.128
	Wed 16/02	360	621.8	2093.0	36.6	28.4	80.8	154.0	5.0	3.4	68.3	1.5	1.8	0.130
	Thur 17/02	361	860.2	2232.3	49.2	30.7	98.0	144.9	4.6	3.5	76.2	0.0	2.0	0.114
	Frid 18/02	362												
	Sat 19/02	363												
	Sun 20/02	364	700.4	2150.4	36.9	38.9	87.4	140.7	3.6	3.4	72.8	2.9	2.1	0.125
	Mon 21/02	365	745.5	2252.8	43.0	38.9	92.3	160.3	5.2	4.9	83.7	2.7	1.8	0.124
	Tues 22/02	366	671.7	2314.2	43.0	36.9	72.9	149.8	5.2	0.0	58.8	2.0	2.0	0.109

	Date	Day	COD (mgCOD/l)				TKN (mg N/l)				FSA (mg N/l)			TKN/
			I	ML	UE	FE	I	ML	UE	FE	I	UE	FE	COD
	Wed 23/02	367	729.1	2478.1	51.2	36.9	85.1	162.4	4.9	4.5	75.6	2.2	2.7	0.117
	Thur 24/02	368												
	Frid 25/02	369												
AVERAGE	**Batch 14/26**		**699.1**	**2294.6**	**46.4**	**38.5**	**84.5**	**150.9**	**4.5**	**3.1**	**70.6**	**1.9**	**2.1**	**0.121**
Batch 15/27	Sat 26/02	370												
	Sun 27/02	371	675.8	2785.3	45.1	43.0	67.8	190.4	3.1	2.4	67.5	2.4	2.4	0.100
	Mon 28/02	372	675.8	2805.8	63.5	55.3	72.1	123.2	5.5	4.6	62.7	2.5	2.8	0.107
	Tues 29/02	373	725.0	2969.6	61.4	34.8	83.2	194.6	5.0	3.2	76.2		2.3	0.115
	Wed 01/03	374	626.7	2498.6	36.9	28.7	77.8	162.4	3.8	1.7	68.9		1.8	0.124
	Thur 02/03	375	709.4	2591.3	53.1	29.7	86.0	156.1	6.3	5.2	76.4		1.8	0.121
	Frid 03/03	376												
	Sat 04/03	377												
	Sun 05/03	378												
	Mon 06/03	379	666.9	2676.2	44.6	23.4	92.1	177.8	5.2	3.4	77.8		2.2	0.138
	Tues 07/03	380	751.9	3037.3	68.0	48.9	84.1	183.4	3.5	2.4	71.1		1.4	0.112
	Wed 08/03	381	649.9	2761.2	55.2	48.9	91.0	163.8	4.2	3.5	76.2		2.1	0.140
	Thur 09/03	382	710.0	2852.3	57.5	34.9	85.7	172.2	5.2	3.4	76.7		2.2	0.121
AVERAGE	**Batch 15/27**		**687.9**	**2775.3**	**53.9**	**38.6**	**82.2**	**169.3**	**4.6**	**3.3**	**72.6**		**2.1**	**0.120**
Batch 16/28	Frid 10/03	383												
	Sat 11/03	384												
	Sun 12/03	385	718.2	2995.9	57.5	39.0	88.6	190.4	4.5	2.4	69.4		2.1	0.123
	Mon 13/03	386												
	Tues 14/03	387	730.5	2995.9	59.5	36.9	85.1	200.9	5.7	4.5	63.6		4.0	0.117
	Wed 15/03	388	742.8	2585.5	45.1	36.9	86.1	192.5	5.3	3.5	70.8		3.2	0.116
	Thur 16/03	389	669.0	2770.2	30.8	22.6	87.4	193.2	5.5	4.8	73.6		4.1	0.131
	Frid 17/03	390												
	Sat 18/03	391												
	Sun 19/03	392	673.3	2677.0	36.5	16.2	88.9	188.3	3.6	2.2	66.9		1.8	0.132
	Mon 20/03	393	717.9	3224.5	75.0	40.6	88.3	177.1	6.2	2.4	75.0		2.1	0.123
	Tues 21/03	394	774.7	2798.6	54.8	26.4	89.9	182.0	5.3	2.9	76.4		2.3	0.116
	Wed 22/03	395	703.2	2755.0	63.7	45.2	90.9	180.6	5.0	1.8	73.4		1.1	0.129
	Thur 23/03	396												
AVERAGE	**Batch 16/28**		**716.2**	**2850.3**	**52.9**	**33.0**	**88.1**	**188.1**	**5.1**	**3.1**	**71.4**		**2.6**	**0.123**
Batch 17/29	Frid 24/03	397												
	Sat 25/03	398												
	Sun 26/03	399	678.5	2796.2	53.5	35.0	41.6	176.4	5.0	2.1	33.6		1.7	0.061
	Mon 27/03	400												
	Tues 28/03	401	673.2	2570.4	44.9	18.4	67.2	180.6	3.4	2.9	58.0		2.8	0.100
	Wed 29/03	402	799.7	3100.8	53.0	44.9	72.8	185.5	4.1	2.8	66.9		1.6	0.091
	Thur 30/03	403	803.8	2856.0	73.4	53.0	78.0	187.6	5.0	3.9	58.0		1.8	0.097
	Frid 31/03	404												
	Sat 01/04	405												
	Sun 02/04	406	783.4	2448.0	61.2	51.0	74.2	149.8	3.6	2.9	66.6		2.7	0.095
	Mon 03/04	407	754.8	2937.6	53.0	44.9	70.0	200.2	5.7	4.2	60.2		2.4	0.093
AVERAGE	**Batch 17/29**		**748.9**	**2784.8**	**56.5**	**41.2**	**67.3**	**180.0**	**4.5**	**3.2**	**57.2**		**2.2**	**0.090**
Batch 18/30	Tues 04/04	408												
	Wed 05/04	409	778.2	2887.7	61.4	49.2	68.0	182.7	5.2	3.2	51.2		2.3	0.087
	Thur 06/04	410	782.3	2949.1	71.7	63.5	65.8	171.5	2.0	1.4	48.7		0.8	0.084
	Frid 07/04	411	876.5	2723.8	53.2	45.1	66.2	172.2	2.8	1.0	52.6		0.8	0.076
	Sat 08/04	412	745.5	2703.4	53.2	36.9	65.0	148.4	1.4	0.8	41.7		0.5	0.087
	Sun 09/04	413	802.8	2785.3	51.2	45.1	61.0	144.2	1.4	0.6	45.4		0.6	0.076
	Mon 10/04	414	856.1	2539.5	43.0	38.9	59.4	147.0	0.8	0.6	45.4		0.5	0.069
	Tues 11/04	415	688.1	2519.0	38.9	34.8	70.0	176.4	4.2	3.6	62.2		1.5	0.102
	Wed 12/04	416	970.8	3010.6	59.4	47.1	65.0	187.6	4.5	0.9	63.8		1.4	0.067
	Thur 13/04	417	729.1	2580.5	75.8	43.0	70.7	175.0	5.3	3.5	56.3		2.0	0.097
	Frid 14/04	418	745.5	2764.8	67.6	36.9	66.5	172.9	3.5	1.4	50.4		1.7	0.089
	Sat 15/04	419												
	Sun 16/04	420	843.8	2887.7	47.1	32.8	87.5	199.5	5.0	3.8	69.2		1.5	0.104
	Mon 17/04	421	770.0	2785.3	53.2	38.9	74.3	196.0	6.2	5.0	59.9		3.4	0.097
AVERAGE	**Batch 18/30**		**799.1**	**2781.4**	**56.3**	**42.7**	**68.3**	**172.8**	**3.5**	**2.1**	**53.9**		**1.4**	**0.086**

	Date	Day	Nitrite (mg N/l)				Nitrate (mg N/l)				Phosphate (mg P/l)				
			An	Ax	Aero	FE	An	Ax	Aero	FE	Ul	An	Ax	Aero	FE
Batch 1/13	Sat 07/08	167													
	Sun 08/08	168													
	Mon 09/08	169													
	Tues 10/08	170	0.1	0.1	3.7	0.7	3.1	0.2	14.9	6.8	27.0	37.5	25.4	16.9	13.7
	Wed 11/08	171	0.1	3.7	6.4	6.8	0.2	5.9	18.2	18.1	29.1	29.1	19.6	14.7	14.4
	Thur12/08	172	0.0	0.1	2.4	1.9	0.1	1.6	10.5	13.7	25.9	30.2	20.3	14.7	14.4
	Frid 13/08	173													
	Sat 14/08	174	0.0	0.0	0.9	1.4	0.1	0.3	2.1	4.9	27.3	32.3	25.2	18.2	20.3
	Sun 15/08	175	0.0	0.1	1.7	2.1	0.1	0.3	4.3	7.5	18.6	29.5	25.6	15.8	15.4
	Mon 16/08	176	0.0	0.5	0.8	1.4	0.2	1.8	14.5	10.6	27.0	30.9	19.3	15.8	15.4
	Tues 17/08	177	0.1	0.1	1.0	0.8	0.3	0.7	14.6	17.2	26.5	31.3	18.9	11.1	11.1
	Wed 18/08	178	0.1	0.1	1.0	0.7	0.3	1.0	17.5	18.4	27.7	29.0	19.9	12.7	11.8
	Thur 19/08	179	0.0	0.1	0.7	0.5	0.2	0.7	16.1	17.9	27.7	31.7	19.6	14.4	14.4
	Frid 20/08	180	0.1	0.1	0.7	0.4	0.2	0.5	14.8	15.9	27.7	33.3	21.5	15.0	13.7
	Sat 21/08	181													
	Sun 22/08	182													
	Mon 23/08	183	0.1	0.2	0.8	0.3	0.2	0.8	16.9	16.2	23.4	27.1	18.0	12.4	13.1
	Tues 24/08	184													
	Wed 25/08	185													
	Thur 26/08	186													
AVERAGE	***Batch 1/13***		***0.1***	***0.5***	***1.8***	***1.5***	***0.5***	***1.2***	***13.1***	***13.4***	***26.2***	***31.1***	***21.2***	***14.7***	***14.3***
Batch 2 /14	Frid 27/08	187													
	Sat 28/08	188													
	Sun 29/08	189	0.0	0.1	0.4	0.4	0.1	2.2	10.3	10.1	22.9	31.5	14.8	4.1	3.7
	Mon 30/08	190	0.0	0.1	0.7	0.2	0.1	1.8	9.3	6.9	28.9	36.6	24.1	8.5	8.5
	Tues 31/08	191													
	Wed 01/09	192													
	Thur 02/09	193													
	Frid 03/09	194													
	Sat 04/09	195													
	Sun 05/09	196													
	Mon 06/09	197	0.0	0.1	0.6	0.4	0.3	1.3	17.9	12.4	25.9	32.6	14.1	5.2	4.4
	Tues 07/09	198	0.0	0.1	0.6	0.4	0.3	2.1	20.1	15.9	27.4	32.6	16.7	6.3	6.3
	Wed 08/09	199	0.0	0.1	0.8	0.3	0.5	2.6	14.2	15.5	24.8	29.2	16.7	10.7	7.8
	Thur 09/09	200	0.0	0.1	0.6	0.5	0.4	4.6	21.4	19.8	27.4	25.2	18.1	15.2	13.3
	Frid 10/09	201													
	Sat 11/09	202													
	Sun 12/09	203													
AVERAGE	***Batch 2/14***		***0.0***	***0.1***	***0.6***	***0.4***	***0.3***	***2.4***	***15.6***	***13.4***	***26.2***	***31.3***	***17.4***	***8.3***	***7.3***
Batch 3/15	Mon 13/09	204													
	Tues 14/09	205													
	Wed 15/09	206													
	Thur 16/09	207	0.0	0.1	0.8	0.6	0.2	3.1	16.8	20.9	25.1	31.0	20.4	14.5	16.6
	Frid 17/09	208													
	Sat 18/09	209													
	Sun 19/09	210													
	Mon 20/09	211													
	Tues 21/09	212	0.0	0.2	0.8	0.4	0.4	6.6	21.8	22.8	33.5	28.9	18.7	13.7	11.6
	Wed 22/09	213	0.0	0.2	0.6	0.3	0.3	6.1	21.3	22.8	33.9	30.7	19.0	15.5	13.4
	Thur 23/09	214													
	Frid 24/09	215													
	Sat 25/09	216													
	Sun 26/09	217													
	Mon 27/09	218													
	Tues 28/09	219													
AVERAGE	***Batch 3/15***		***0.0***	***0.2***	***0.7***	***0.4***	***0.3***	***5.3***	***20.0***	***22.2***	***30.8***	***30.2***	***19.4***	***14.6***	***13.9***
Batch 4/16	Wed 29/09	220	0.0	0.2	2.4	3.3	0.1	3.2	14.8	15.4	26.9	29.1	24.5	23.3	22.8
	Thur 30/09	221	0.0	0.2	1.5	1.0	0.2	1.0	13.0	13.7	27.1	30.3	22.6	17.0	18.9
	Frid 1/10	222													
	Sat 2/10	223													

	Date	Day	Nitrite (mg N/l)				Nitrate (mg N/l)				Phosphate (mg P/l)				
			An	Ax	Aero	FE	An	Ax	Aero	FE	UI	An	Ax	Aero	FE
	Sun 3/10	224	0.0	0.1	0.7	0.4	0.1	1.2	13.6	15.0	25.6	29.5	20.4	11.6	14.5
	Mon 4/10	225													
	Tues 5/10	226	0.0	0.1	0.7	0.5	0.1	0.7	13.9	13.9	25.0	32.8	19.5	8.7	7.7
	Wed 6/10	227	0.0	0.1	0.6	0.4	0.1	0.5	12.3	11.7	23.6	32.9	18.2	9.9	9.5
	Thur 7/10	228	0.0	0.2	0.6	0.3	0.1	0.9	12.7	12.2	21.5	45.8	30.5	11.0	10.6
	Frid 8/10	229													
	Sat 9/10	230													
	Sun 10/10	231													
	Mon 11/10	232													
AVERAGE	***Batch 4/16***		***0.0***	***0.1***	***1.1***	***1.0***	***0.1***	***1.2***	***13.4***	***13.6***	***25.0***	***33.4***	***22.6***	***13.6***	***14.0***
Batch 5/17	Tues 12/10	233													
	Wed 13/10	234	0.0	0.1	0.3	0.2	0.0	0.0	8.9	9.0	24.0	29.4	18.6	10.2	12.2
	Thur 14/10	235	0.0	0.1	0.3	0.2	0.1	0.4	10.1	8.2	27.1	36.0	20.1	10.2	10.6
	Frid 15/10	236													
	Sat 16/10	237													
	Sun 17/10	238	0.0	0.1	0.2	0.2	0.2	0.1	9.0	8.6	24.2	36.0	22.6	15.3	13.1
	Mon 18/10	239													
	Tues 19/10	240	0.1	0.1	0.3	0.1	0.0	0.5	9.5	8.6	25.0	37.9	21.1	10.2	11.0
	Wed 20/10	241	0.0	0.1	0.2	0.1	0.0	0.3	8.9	8.9	27.5	42.5	24.7	13.1	10.8
	Tues 21/10	242	0.1	0.1	0.2	0.2	0.1	0.3	5.2	7.8	28.2	30.2	17.7	10.5	12.6
	Frid 22/10	243													
	Sat 23/10	244													
	Sun 24/10	245	0.1	0.2	0.2	0.2	0.1	0.4	7.2	8.3	24.5	20.4	20.0	19.4	17.7
	Mon 25/10	246	0.1	0.8	0.5	0.3	0.1	0.6	8.0	9.2	22.8	29.6	24.1	18.3	20.7
AVERAGE	***Batch 5/17***		***0.1***	***0.2***	***0.3***	***0.2***	***0.1***	***0.3***	***8.3***	***8.6***	***25.4***	***34.5***	***21.3***	***12.6***	***13.0***
Batch 6/18	Tues 26/10	247													
	Wed 27/10	248	0.0	0.1	0.2	0.2	0.1	0.2	7.4	8.3	24.8	35.3	24.5	16.3	16.6
	Tues 28/10	249	0.0	0.1	0.3	0.2	0.1	0.4	9.0	8.2	24.8	34.3	23.4	15.3	15.6
	Frid 29/10	250	0.0	0.1	0.2	0.1	0.1	0.1	8.5	8.8	26.2	33.0	21.4	12.9	13.3
	Sat 30/10	251													
	Sun 31/10	252	0.0	0.0	0.2	0.2	0.0	0.3	9.4	7.5	26.6	36.4	23.1	11.6	13.6
	Mon 1/11	253													
	Tues 2/11	254	0.0	0.1	0.2	0.2	0.0	0.6	8.7	7.9	29.0	37.7	22.1	13.6	13.6
	Wed 3/11	255	0.0	0.0	0.2	0.2	0.1	0.6	8.6	7.9	28.9	35.3	21.7	12.2	13.6
	Thur 4/10	256	0.0	0.1	0.1	0.1	0.0	0.2	9.7	8.4	30.6	41.8	25.5	13.6	13.6
	Frid 5/11	257	0.0	0.0	0.2	0.2	0.0	0.1	7.2	7.0	25.5	35.2	23.4	14.1	14.5
	Sat 6/11	258													
	Sun 7/11	259	0.0	0.1	0.5	0.3	0.1	0.2	6.9	6.3	25.9	34.5	26.6	17.6	17.6
	Mon 8/11	260													
AVERAGE	***Batch 6/18***		***0.0***	***0.1***	***0.2***	***0.2***	***0.1***	***0.3***	***8.4***	***7.8***	***26.9***	***35.9***	***23.5***	***14.1***	***14.7***
Batch 7/19	Tues 9/11	261													
	Wed 10/11	262	0.1	0.3	0.3	0.1	0.1	0.6	9.4	8.2	23.8	36.6	22.4	14.5	14.1
	Thur 11/11	263	0.0	0.1	1.6	0.5	0.1	0.2	7.0	10.2	23.8	33.8	25.5	18.3	15.5
	Frid 12/11	264													
	Sat 13/11	265													
	Sun 14/11	266	0.1	0.4	0.3	0.2	0.1	1.2	12.0	11.6	12.1	26.2	17.2	11.0	14.1
	Mon 15/11	267	0.1	0.4	0.4	0.2	0.1	1.7	13.6	13.9	25.2	31.0	18.6	12.8	10.7
	Tues 16/11	268	0.1	0.3	0.4	0.2	0.1	1.6	13.5	15.5	21.4	30.3	24.1	13.8	13.1
	Wed 17/11	269	0.0	0.3	0.4	0.2	0.1	0.7	12.9	14.5	21.0	31.0	23.1	12.8	12.4
	Thur 18/11	270	0.0	0.2	0.5	0.2	0.1	0.3	10.6	12.0	17.6	26.9	20.0	10.3	10.7
	Frid 19/11	271	0.0	0.2	0.4	0.2	0.1	0.4	10.7	11.6	23.4	31.4	19.3	10.7	10.3
AVERAGE	***Batch 7/19***		***0.0***	***0.3***	***0.5***	***0.2***	***0.1***	***0.9***	***11.2***	***12.2***	***21.0***	***30.9***	***21.3***	***13.0***	***12.6***
Batch 8/20	Sat 20/11	272													
	Sun 21/11	273	0.1	0.0	0.2	0.1	0.3	0.5	8.0	8.5	26.8	29.6	20.5	12.9	13.2
	Mon 22/11	274													
	Tues 23/11	275	0.0	0.1	0.2	0.1	0.1	0.3	8.4	9.2	30.3	33.1	25.1	17.1	14.6
	Wed 24/11	276	0.0	0.1	0.2	0.1	0.1	0.2	7.7	8.2	24.7	32.4	20.2	12.2	13.9
	Thur 25/11	277	0.0	0.1	0.2	0.1	0.1	0.4	7.5	8.6	26.1	31.7	20.9	12.5	11.8
	Frid 26/11	278	0.0	0.1	0.2	0.1	0.1	0.2	8.1	9.4	26.4	32.7	21.9	13.2	12.9
	Sat 27/11	279													

	Date	Day	Nitrite (mg N/l)				Nitrate (mg N/l)				Phosphate (mg P/l)				
			An	Ax	Aero	FE	An	Ax	Aero	FE	Ui	An	Ax	Aero	FE
	Sun 28/11	280	0.1	0.0	0.2	0.1	0.1	0.3	8.1	9.0	25.1	35.5	21.6	12.2	13.2
	Mon 29/11	281													
	Tues 30/11	282	0.1	0.1	0.2	0.2	0.2	0.3	8.7	7.9	23.0	33.8	22.3	13.9	13.9
	Wed 1/12	283	0.0	0.1	0.2	0.2	0.1	0.2	9.1	8.5	26.4	34.5	23.0	15.3	15.7
	Thur 2/12	284	0.1	0.0	0.2	0.2	0.1	0.2	8.7	8.2	23.3	33.4	20.5	11.8	12.2
AVERAGE	***Batch 8/20***		***0.1***	***0.1***	***0.2***	***0.1***	***0.1***	***0.3***	***8.3***	***8.6***	***25.8***	***32.9***	***21.8***	***13.5***	***13.5***
Batch 9 /21	Frid 3/12	285													
	Sat 4/12	286													
	Sun 5/12	287													
	Mon 6/12	288	0.1	0.1	0.2	0.2	0.3	0.4	6.4	8.8	22.5	32.8	21.2	14.0	13.7
	Tues 7/11	289	0.0	0.1	0.2	0.1	0.2	0.3	7.2	8.1	24.6	32.8	21.5	14.0	13.7
	Wed 8/12	290	0.0	0.0	0.1	0.1	0.1	0.3	5.9	8.2	25.3	33.4	22.5	15.7	14.3
	Thur 9/12	291	0.0	0.0	0.1	0.1	0.1	0.2	7.7	7.5	29.7	35.2	22.5	14.3	14.7
	Frid 10/12	292													
	Sat 11/12	293													
	Sun 12/12	294	0.1	0.1	0.1	0.1	0.2	0.3	7.4	7.8	25.3	34.1	23.2	16.0	17.4
	Mon 13/12	295													
	Tues 14/12	296	0.0	0.1	0.2	0.1	0.1	0.3	7.4	7.3	23.7	33.4	22.5	15.5	16.7
AVERAGE	***Batch 9 /21***		***0.1***	***0.1***	***0.1***	***0.1***	***0.2***	***0.3***	***7.0***	***7.9***	***25.2***	***33.6***	***22.2***	***14.9***	***15.1***
Batch 10/22	Wed 15/12	297													
	Thur 16/12	298													
	Frid 17/12	299													
	Sat 18/12	300													
	Sun 19/12	301	0.1	0.4	0.4	0.1	0.5	0.6	10.1	11.3	24.8	29.7	20.8	14.6	15.5
	Mon 20/12	302	0.1	1.3	0.5	0.2	0.2	1.3	11.2	12.2	25.4	30.7	20.8	15.2	14.9
	Tues 21/12	303	0.1	1.2	0.5	0.1	0.2	1.1	10.7	12.5	23.2	28.2	20.1	15.5	14.6
	Wed 22/12	304	0.1	0.8	0.3	0.2	0.1	0.3	12.1	12.3	25.4	31.3	18.9	13.9	15.5
	Thur 23/12	305	0.1	0.9	0.5	0.1	0.1	0.9	10.7	11.8	23.8	29.1	18.9	13.9	13.9
	Frid 24/12	306													
	Sat 25/12	307													
	Sun 26/12	308	0.1	0.4	0.4	0.6	0.1	0.6	9.8	11.5	24.8	26.3	18.6	13.3	16.4
	Mon 27/12	309													
	Tues 28/12	310													
	Wed 29/12	311	0.2	0.8	0.5	0.1	0.3	0.9	9.5	10.1	24.5	27.3	19.2	15.5	13.9
	Thur 30/12	312	0.1	1.2	0.5	0.2	0.1	1.9	10.0	10.4	24.8	27.3	18.6	15.2	14.9
AVERAGE	***Batch 10/22***		***0.1***	***0.9***	***0.5***	***0.2***	***0.2***	***1.0***	***10.5***	***11.5***	***24.6***	***28.7***	***19.5***	***14.6***	***14.9***
Batch 11/23	Frid 31/12	313													
	Sat 1/01	314													
	Sun 2/01	315													
	Mon 3/01	316	0.1	2.2	3.0	3.7	0.3	7.1	19.2	19.5	22.6	22.3	18.9	15.2	15.2
	Tues 4/01	317	0.1	0.9	0.4	0.7	0.1	3.2	14.0	19.4	22.3	23.5	17.3	14.6	14.2
	Wed 5/01	318	0.1	0.4	0.5	0.2	0.1	1.0	10.5	12.1	22.3	25.1	18.9	16.7	14.9
	Thur 6/01	319	0.0	0.4	0.5	0.2	0.1	0.9	11.8	10.8	20.1	26.9	18.3	15.2	14.6
	Frid 7/01	320	0.1	1.0	0.5	0.2	0.1	1.5	11.9	12.4	22.3	24.5	15.8	13.0	13.0
	Sat 8/01	321													
	Sun 9/01	322	0.1	0.8	0.5	0.1	0.3	1.3	11.3	13.4	24.6	26.8	19.4	16.0	16.0
	Mon 10/01	323	0.1	0.8	0.6	0.1	0.2	1.2	12.4	12.8	24.6	27.4	20.0	16.6	16.0
	Tues 11/01	324	0.1	0.7	0.4	0.1	0.2	1.0	12.6	12.5	24.6	27.1	19.7	16.6	17.2
	Wed 12/01	325	0.1	0.3	0.3	0.1	0.2	0.4	11.4	12.4	21.9	27.1	20.0	17.2	16.9
	Thur 13/01	326	0.0	0.2	0.5	0.1	0.1	0.1	11.0	11.1	23.4	26.2	20.0	15.7	17.6
	Frid 14/01	327	0.1	0.6	0.3	0.1	0.3	1.1	11.8	11.4	24.3	26.5	20.0	17.2	16.9
AVERAGE	***Batch 11/23***		***0.1***	***0.8***	***0.7***	***0.5***	***0.2***	***1.7***	***12.5***	***13.4***	***23.0***	***25.8***	***18.9***	***15.8***	***15.7***
Batch 12/24	Sat 15/01	328													
	Sun 16/01	329													
	Mon 17/01	330	0.1	0.5	0.3	0.1	0.7	2.1	10.8	10.7	22.3	27.8	16.2	14.0	13.1
	Tues 18/01	331													
	Wed 19/01	332	0.0	0.1	0.6	4.3	0.1	0.4	12.1	12.0	25.6	25.9	16.5	10.1	12.8
	Thur 20/01	333	0.1	0.1	0.4	0.2	0.2	0.4	10.8	12.3	25.9	29.3	17.1	12.5	11.0
	Frid 21/01	334	0.1	0.5	0.5	0.1	0.2	0.8	11.9	11.7	25.3	27.2	18.9	14.6	13.1

	Date	Day	Nitrite (mg N/l)				Nitrate (mg N/l)				Phosphate (mg P/l)				
			An	Ax	Aero	FE	An	Ax	Aero	FE	Ul	An	Ax	Aero	FE
	Sat 22/01	335													
	Sun 23/01	336	0.2	1.0	0.7	0.1	0.3	1.3	14.7	15.1	26.2	30.5	21.7	17.4	16.5
	Mon 24/01	337	0.1	0.6	0.3	0.5	0.2	1.0	11.7	14.4	24.9	29.2	20.7	16.2	16.2
	Tues 25/01	338	0.2	0.3	0.3	0.1	0.1	0.8	12.4	14.2	25.2	30.1	20.1	15.3	15.3
	Wed 26/01	339	0.1	0.7	0.3	0.1	0.1	1.1	14.4	15.4	26.8	31.9	18.3	17.4	16.2
	Thur 27/01	340	0.1	0.8	0.4	0.2	0.1	1.0	14.1	14.3	24.6	30.7	21.3	17.4	17.1
	Frid 28/01	341													
AVERAGE	***Batch 12/24***		***0.1***	***0.5***	***0.4***	***0.6***	***0.2***	***1.0***	***12.5***	***13.3***	***25.2***	***29.2***	***19.0***	***15.0***	***14.6***
Batch 13/25	Sat 29/01	342													
	Sun 30/01	343	0.0	0.1	0.1	0.1	0.1	0.2	5.7	6.4	21.3	27.1	19.8	16.8	16.2
	Mon 31/01	344	0.0	0.1	0.1	0.1	0.1	0.2	7.3	6.4	24.6	29.5	20.7	16.8	16.2
	Tues 01/02	345	0.0	0.0	0.2	0.2	0.1	0.1	8.0	7.8	29.4	31.8	21.4	16.8	15.9
	Wed 02/02	346	0.0		0.1	0.1	0.1		7.2	7.7					
	Thur 03/02	347													
	Frid 04/02	348													
	Sat 05/02	349	0.0	0.1	0.2	0.2	0.1	0.3	7.0	7.5	27.2	33.6	25.1	19.9	20.8
	Sun 06/02	350	0.0	0.1	0.2	0.1	0.1	0.3	7.3	8.3	28.1	32.1	22.9	17.4	17.7
	Mon 07/02	351	0.0	0.1	0.2	0.2	0.1	0.3	10.3	9.1	32.4	36.4	24.5	17.8	16.2
	Tues 08/02	352	0.0	0.1	0.2	0.1	0.1	0.1	8.3	9.3	30.6	36.1	25.1	19.0	19.0
	Wed 09/02	353	0.0	0.1	0.4	0.1	0.1	0.3	9.1	9.7	32.1	37.3	26.3	20.5	19.9
	Thur 10/02	354	0.0	0.1	0.1	0.1	0.1	0.2	9.7	9.6	32.1	36.1	23.6	16.8	17.4
	Frid 11/02	355													
AVERAGE	***Batch 13/25***		***0.0***	***0.1***	***0.2***	***0.1***	***0.1***	***0.2***	***8.0***	***8.2***	***28.7***	***33.3***	***23.3***	***18.0***	***17.7***
Batch 14/26	Sat 12/02	356													
	Sun 13/02	357													
	Mon 14/02	358	0.0	0.8	0.7	0.6	0.2	4.3	16.2	20.2	25.3	30.8	20.1	14.3	12.8
	Tues 15/02	359	0.0	0.8	1.0	0.8	0.1	4.3	16.7	18.1	28.4	34.2	24.1	17.7	16.5
	Wed 16/02	360	0.1	0.7	0.8	0.4	0.2	3.4	15.7	19.5	26.9	33.6	23.2	18.0	18.0
	Thur 17/02	361	0.1	0.6	1.2	0.4	0.1	3.5	15.4	18.3	28.4	33.9	23.2	17.7	17.4
	Frid 18/02	362													
	Sat 19/02	363													
	Sun 20/02	364	0.1	0.4	1.0	0.4	0.1	2.0	14.5	15.0	26.6	36.6	24.1	17.4	17.1
	Mon 21/02	365	0.1	0.4	0.7	0.2	0.1	0.8	14.2	16.5	32.6	35.3	23.2	16.6	14.8
	Tues 22/02	366	0.0	0.1	0.5	0.2	0.1	0.5	14.4	15.4	29.2	36.5	25.6	19.0	18.7
	Wed 23/02	367	0.0	0.3	0.5	0.3	0.1	0.6	14.1	14.6	35.9	39.5	26.5	19.3	17.2
	Thur 24/02	368													
	Frid 25/02	369													
AVERAGE	***Batch 14/26***		***0.0***	***0.5***	***0.8***	***0.4***	***0.1***	***2.4***	***15.1***	***17.2***	***29.1***	***35.0***	***23.8***	***17.5***	***16.6***
Batch 15/27	Sat 26/02	370													
	Sun 27/02	371	0.1	0.1	0.1	0.1	0.1	0.3	10.8	10.8	25.6	33.8	20.5	13.6	14.2
	Mon 28/02	372	0.0	0.1	0.4	0.1	0.2	2.0	12.0	12.0	23.3	32.9	16.1	8.5	8.9
	Tues 29/02	373	0.1	0.1	0.1	0.1	0.1	2.1	15.9	14.9	25.6	35.8	18.4	10.2	8.9
	Wed 01/03	374	0.0	0.3	0.6	0.2	0.2	4.7	18.7	18.7	26.0	35.8	19.4	12.5	10.8
	Thur 02/03	375	0.1	0.5	0.6	0.2	0.2	6.0	20.2	22.0	26.0	36.1	21.0	15.1	13.1
	Frid 03/03	376													
	Sat 04/03	377													
	Sun 05/03	378													
	Mon 06/03	379	0.0	0.3	0.1	0.1	0.1	0.9	14.0	15.2	26.0	34.8	16.4	8.2	9.2
	Tues 07/03	380	0.0	0.3	0.4	0.2	0.1	3.0	16.9	18.3	26.0	37.3	20.2	12.6	10.7
	Wed 08/03	381	0.0	0.7	0.2	0.1	0.1	3.0	15.7	20.8	26.6	39.5	22.3	12.6	11.6
	Thur 09/03	382	0.0	0.7	0.2	0.2	1.0	3.7	17.2	19.8	25.7	35.8	20.8	13.5	12.6
AVERAGE	***Batch 15/27***		***0.0***	***0.4***	***0.3***	***0.2***	***0.2***	***2.9***	***15.7***	***18.9***	***25.6***	***35.8***	***19.5***	***11.9***	***11.1***
Batch 16/28	Frid 10/03	383													
	Sat 11/03	384													
	Sun 12/03	385	0.1	1.0	0.2	0.1	0.1	3.5	16.2	16.6	25.4	30.9	19.3	13.8	13.5
	Mon 13/03	386													
	Tues 14/03	387	0.0	0.3	0.3	0.6	0.1	0.5	10.7	10.2	25.6	38.6	22.5	14.2	12.7
	Wed 15/03	388	0.0	0.3	0.2	0.7	0.1	0.5	15.6	13.4	24.4	37.3	21.3	11.7	12.0
	Thur 16/03	389	0.0	0.0	1.1	0.3	0.1	0.1	4.8	15.0	25.3	37.0	29.9	16.7	10.2
	Frid 17/03	390													

	Date	Day	Nitrite (mg N/l)				Nitrate (mg N/l)				Phosphate (mg P/l)				
			An	Ax	Aero	FE	An	Ax	Aero	FE	Ui	An	Ax	Aero	FE
	Sat 18/03	391													
	Sun 19/03	392	0.0	0.4	1.1	0.2	0.1	0.2	14.8	17.3	25.0	39.5	22.8	13.3	12.7
	Mon 20/03	393	0.1	0.5	0.2	0.1	0.3	1.9	18.2	17.1	26.8	41.4	23.1	14.2	13.3
	Tues 21/03	394	0.0	0.5	0.1	0.1	0.3	2.2	19.7	18.8	25.7	43.7	22.7	11.2	11.5
	Wed 22/03	395	0.0	0.5	0.1	0.2	0.2	3.5	20.2	20.1	24.0	40.6	21.7	10.2	9.8
	Thur 23/03	396													
AVERAGE	***Batch 16/28***		***0.0***	***0.4***	***0.4***	***0.3***	***0.2***	***1.6***	***15.0***	***16.1***	***25.3***	***38.6***	***22.9***	***13.1***	***12.0***
Batch 17/29	Frid 24/03	397													
	Sat 25/03	398													
	Sun 26/03	399	0.0	0.0	0.2	0.1	0.1	0.1	4.5	5.5	22.6	38.4	22.0	10.8	12.4
	Mon 27/03	400													
	Tues 28/03	401	0.1	0.1	0.2	0.1	0.2	0.1	8.0	8.3	24.5	39.7	20.8	10.5	10.8
	Wed 29/03	402	0.2	0.1	0.8	0.1	0.2	0.2	7.9	8.4	25.4	40.6	19.8	6.2	7.4
	Thur 30/03	403	0.0	0.1	0.5	0.1	0.1	0.4	9.6	8.7	25.7	41.5	21.1	9.3	7.1
	Frid 31/03	404													
	Sat 01/04	405													
	Sun 02/04	406	0.0	0.1	0.2	0.3	0.2	0.1	9.7	9.7	25.7	49.6	18.3	9.6	6.8
	Mon 03/04	407	0.2	0.1	0.1	0.3	0.1	0.1	9.2	9.4	25.4	41.5	18.3	3.7	4.6
AVERAGE	***Batch 17/29***		***0.1***	***0.1***	***0.3***	***0.1***	***0.1***	***0.1***	***8.1***	***8.3***	***24.9***	***41.9***	***20.0***	***8.4***	***8.2***
Batch 18/30	Tues 04/04	408													
	Wed 05/04	409	0.0	0.2	0.2	0.1	0.2	0.8	10.2	11.0	26.0	43.0	19.2	4.9	4.6
	Thur 06/04	410	0.0	0.0	0.1	0.1	0.0	0.4	9.4	9.9	30.9	44.2	19.5	5.3	4.6
	Frid 07/04	411	0.0	0.0	0.1	0.1	0.0	0.3	9.3	10.0	26.3	45.2	23.2	9.6	6.8
	Sat 08/04	412	0.1	0.0	0.0	0.1	0.2	0.6	9.6	10.8	26.6	43.0	22.0	8.7	7.1
	Sun 09/04	413	0.0	0.0	0.1	0.1	0.0	0.2	9.2	9.6	25.7	44.5	21.3	9.3	9.3
	Mon 10/04	414	0.0	0.1	0.2	0.2	0.0	0.3	9.2	9.8	25.7	47.3	25.7	13.3	9.6
	Tues 11/04	415	0.0	0.1	0.1	1.2	0.1	0.6	9.7	9.2	25.9	41.1	22.3	8.9	9.8
	Wed 12/04	416	0.0	0.2	0.1	0.1	0.0	1.3	9.9	10.7	26.2	28.3	16.4	9.8	8.6
	Thur 13/04	417	0.0	0.1	0.1	0.2	0.1	0.2	10.5	10.3	27.1	34.2	21.7	13.4	12.8
	Frid 14/04	418	0.1	0.1	0.1	0.1	0.2	0.2	9.2	10.3	26.2	44.3	20.8	8.3	8.9
	Sat 15/04	419													
	Sun 16/04	420	0.0	0.4	0.1	0.1	0.1	1.1	10.3	7.3	26.2	41.7	20.8	11.0	8.9
	Mon 17/04	421	0.1	0.7	0.1	0.1	0.1	1.0	10.7	11.3	29.2	43.7	22.6	11.0	10.4
AVERAGE	***Batch 18/30***		***0.0***	***0.1***	***0.1***	***0.2***	***0.1***	***0.6***	***9.8***	***10.0***	***26.8***	***41.7***	***21.3***	***9.5***	***8.5***

	Date	Day	MLSS (mg/l)	MLVSS (mg/l)	COD/ VSS	TKN/ VSS	OUR (mg/l/h)	DSVI (ml/g)	pH An	pH Aero
Batch 1/13	Sat 07/08	167								
	Sun 08/08	168								
	Mon 09/08	169								
	Tues 10/08	170	1868.0	1506.0	1.62	0.07	26.6	128.5		
	Wed 11/08	171	2390.0	1962.0	1.34	0.08	39.65	117.2		
	Thur12/08	172	2396.0	1970.0	0.93	0.00	26.4	112.7		
	Frid 13/08	173								
	Sat 14/08	174	2290.0	1898.0	1.50	0.10	41.3	126.6		
	Sun 15/08	175	2280.0	1888.0	1.49	0.17	32.7	127.2		
	Mon 16/08	176	2292.0	1860.0	1.49	0.08		126.5		
	Tues 17/08	177	2324.0	1922.0	1.42	0.08	35.4	111.9		
	Wed 18/08	178	2300.0	1888.0	1.42	0.08	37.2	104.3		
	Thur 19/08	179	2338.0	1896.0	1.53	0.07	38.3	102.7		
	Frid 20/08	180	2122.0	1786.0	1.47	0.08	42.0	103.7		
	Sat 21/08	181								
	Sun 22/08	182								
	Mon 23/08	183	1890.0	1646.0	1.46	0.09	44.6	105.8		
	Tues 24/08	184								
	Wed 25/08	185								
	Thur 26/08	186								
AVERAGE	***Batch 1/13***		***2226.4***	***1838.4***	***1.42***	***0.08***	***32.4***	***115.2***		
Batch 2 /14	Frid 27/08	187								
	Sat 28/08	188								
	Sun 29/08	189	2392.0	1940.0	1.33	0.00	65.3	83.6		
	Mon 30/08	190	2364.0	1962.0	***0.66***	0.00	58.9			
	Tues 31/08	191								
	Wed 01/09	192								
	Thur 02/09	193								
	Frid 03/09	194								
	Sat 04/09	195								
	Sun 05/09	196								
	Mon 06/09	197	2118.0	1662.0	1.66	0.11	32.9	75.5		
	Tues 07/09	198	2044.0	1636.0	1.45	0.09	29.9	78.3		
	Wed 08/09	199	1852.0	1540.0	1.49	0.09	25.2	64.8		
	Thur 09/09	200	1846.0	1486.0	1.43	0.10	21.9	65.0		
	Frid 10/09	201								
	Sat 11/09	202								
	Sun 12/09	203								
AVERAGE	***Batch 2/14***		***2102.7***	***1704.3***	***1.58***	***0.10***	***39.0***	***73.4***		
Batch 3/15	Mon 13/09	204								
	Tues 14/09	205								
	Wed 15/09	206								
	Thur 16/09	207	1782.0	1478.0	0.97	0.06	26.4	84.2		
	Frid 17/09	208								
	Sat 18/09	209								
	Sun 19/09	210								
	Mon 20/09	211								
	Tues 21/09	212	1996.0	1642.0	1.41	0.10	29.4	100.2		
	Wed 22/09	213	2230.0	1752.0	1.50	0.13	32.1	98.7		
	Thur 23/09	214								
	Frid 24/09	215								
	Sat 25/09	216								
	Sun 26/09	217								
	Mon 27/09	218								
	Tues 28/09	219								
AVERAGE	***Batch 3/15***		***2002.7***	***1624.0***	***1.31***	***0.10***	***29.3***	***94.3***		

	Date	Day	MLSS (mg/l)	MLVSS (mg/l)	COD/ VSS	TKN/ VSS	OUR (mg/l/h)	DSVI (ml/g)	pH An	pH Aero
Batch 4/16	Wed 29/09	220	1602.0	1328.0	1.53	0.11	35.2	118.6		
	Thur 30/09	221	1544.0	1282.0	1.51	0.08		129.5		
	Frid 1/10	222								
	Sat 2/10	223								
	Sun 3/10	224	2362.0	1940.0	1.53	0.10	37.4	101.6		
	Mon 4/10	225								
	Tues 5/10	226	2174.0	1786.0	1.55	0.10	38.1	119.6		
	Wed 6/10	227	2474.0	2026.0	1.38	0.10	36.3	109.1		
	Thur 7/10	228	2242.0	1832.0	1.51	0.09	36.4	107.0		
	Frid 8/10	229								
	Sat 9/10	230								
	Sun 10/10	231								
	Mon 11/10	232								
AVERAGE	***Batch 4/16***		***2066.3***	***1699.0***	***1.50***	***0.10***	***36.7***	***114.3***		
Batch 5/17	Tues 12/10	233								
	Wed 13/10	234	2076.0	1682.0	1.45	0.11	33.2	120.4		
	Thur 14/10	235	2228.0	1796.0	1.39	0.10	33.7	125.7		
	Frid 15/10	236								
	Sat 16/10	237								
	Sun 17/10	238	1998.0	1604.0	1.37	0.12	30.5	110.1		
	Mon 18/10	239								
	Tues 19/10	240	2104.0	1676.0	1.51	0.08	30.7	95.1		
	Wed 20/10	241	2084.0	1638.0	1.57	0.10	28.4	105.6		
	Tues 21/10	242	2236.0	1738.0	1.43	0.10	28.1	120.8		
	Frid 22/10	243								
	Sat 23/10	244								
	Sun 24/10	245	2296.0	1816.0	1.46	0.10	31.2	108.9		
	Mon 25/10	246	2004.0	1634.0	1.42	0.10	32.4	109.8		
AVERAGE	***Batch 5/17***		***2128.3***	***1698.0***	***1.45***	***0.10***	***31.0***	***112.0***		
Batch 6/18	Tues 26/10	247								
	Wed 27/10	248	1690.0	1404.0	1.59	0.11	28.0	130.2		
	Tues 28/10	249	1898.0	1518.0	1.56	0.10	31.3	115.9		
	Frid 29/10	250	1908.0	1554.0	1.78	0.10	31.2	125.8		
	Sat 30/10	251								
	Sun 31/10	252	2084.0	1678.0	1.55	0.10	33.0	120.0		
	Mon 1/11	253								
	Tues 2/11	254	2134.0	1694.0	1.52	0.10	30.9	121.8		
	Wed 3/11	255	2126.0	1710.0	1.57	0.10	32.0	117.6		
	Thur 4/10	256					31.7			
	Frid 5/11	257	1748.0	1392.0	1.59	0.10	30.8	125.9		
	Sat 6/11	258								
	Sun 7/11	259	1982.0	1592.0	1.37	0.10	30.8	100.9		
	Mon 8/11	260								
AVERAGE	***Batch 6/18***		***1946.3***	***1567.7***	***1.57***	***0.10***	***31.1***	***119.8***		
Batch 7/19	Tues 9/11	261								
	Wed 10/11	262	2138.0	1700.0	1.53	0.10	32.6	112.3		
	Thur 11/11	263	1592.0	1282.0	1.40	0.10	32.7	163.3		
	Frid 12/11	264								
	Sat 13/11	265								
	Sun 14/11	266	1810.0	1454.0	1.43	0.11	29.1	110.5		
	Mon 15/11	267	1764.0	1438.0	1.28	0.11	32.0	107.7		
	Tues 16/11	268	1626.0	1318.0	1.60	0.11	33.9	123.0		
	Wed 17/11	269	1810.0	1588.0	1.48	0.10	34.9	121.5		
	Thur 18/11	270	1842.0	1500.0	1.25	0.13	32.5	108.6		
	Frid 19/11	271	1640.0	1276.0	1.33	0.10	30.6	122.0		
AVERAGE	***Batch 7/19***		***1777.8***	***1444.5***	***1.42***	***0.11***	***32.3***	***121.1***		

	Date	Day	MLSS (mg/l)	MLVSS (mg/l)	COD/VSS	TKN/VSS	OUR (mg/l/h)	DSVI (ml/g)	pH An	pH Aero
Batch 8/20	Sat 20/11	272								
	Sun 21/11	273	1648.0	1308.0	1.57	0.12	29.0	121.4		
	Mon 22/11	274								
	Tues 23/11	275	1866.0	1526.0	1.58	0.11	31.6	128.6		
	Wed 24/11	276	1940.0	1562.0	1.42	0.10	25.0	113.4		
	Thur 25/11	277	2012.0	1616.0	1.30	0.10	30.8	109.3		
	Frid 26/11	278	1958.0	1586.0	1.29	0.12	26.9	112.4		
	Sat 27/11	279								
	Sun 28/11	280	2188.0	1754.0	1.55	0.09	29.3	100.5		
	Mon 29/11	281								
	Tues 30/11	282	2064.0	1676.0	1.47	0.09	26.7	101.7		
	Wed 1/12	283	2120.0	1746.0	1.31	0.08	31.6	113.2		
	Thur 2/12	284	2098.6	1710.0	1.29	0.09	32.5	114.4		
AVERAGE	***Batch 8/20***		***1988.3***	***1609.3***	***1.42***	***0.10***	***29.3***	***112.8***		
Batch 9 /21	Frid 3/12	285								
	Sat 4/12	286								
	Sun 5/12	287								
	Mon 6/12	288	2200.0	1766.0	1.39	0.11	33.1	104.5		
	Tues 7/11	289	2210.0	1778.0	1.41	0.10	31.8	99.5		
	Wed 8/12	290	2302.0	1860.0	1.46	0.10	32.1	104.3		
	Thur 9/12	291	2186.0	1752.0	1.35	0.11	31.2	114.4		
	Frid 10/12	292								
	Sat 11/12	293								
	Sun 12/12	294	2286.0	1862.0	1.31	0.10	30.3	113.7		
	Mon 13/12	295								
	Tues 14/12	296	2060.0	1666.0	1.51	0.09	32.4	135.9		
AVERAGE	***Batch 9 /21***		***2207.3***	***1780.7***	***1.40***	***0.10***	***31.8***	***112.1***		
Batch 10/22	Wed 15/12	297								
	Thur 16/12	298								
	Frid 17/12	299								
	Sat 18/12	300								
	Sun 19/12	301	2086.0	1666.0	1.45	0.09	34.1	143.8		
	Mon 20/12	302	2158.0	1728.0	1.42	0.10	32.1	139.0		
	Tues 21/12	303	2018.0	1608.0	1.47	0.10	30.4	148.7		
	Wed 22/12	304	2206.0	1746.0	1.31	0.09	38.7	140.5		7.59
	Thur 23/12	305	2170.0	1720.0	1.34	0.10	38.6	147.5		7.76
	Frid 24/12	306								
	Sat 25/12	307								
	Sun 26/12	308	2258.0	1780.0	1.44	0.10	39.9	141.7		7.87
	Mon 27/12	309								
	Tues 28/12	310								
	Wed 29/12	311	2144.0	1698.0	1.40	0.10	33.7	144.6		7.85
	Thur 30/12	312	2060.0	1626.0	1.34	0.09	36.5	155.3		7.78
AVERAGE	***Batch 10/22***		***2137.5***	***1696.5***	***1.40***	***0.10***	***35.5***	***145.1***		7.77
Batch 11/23	Frid 31/12	313								
	Sat 1/01	314								
	Sun 2/01	315								
	Mon 3/01	316	2058.0	1646.0	1.49	0.09	43.6	165.2		7.72
	Tues 4/01	317	2026.0	1632.0	1.40	0.09	40.9	167.8		7.79
	Wed 5/01	318	1920.0	1564.0	1.41	0.10	37.3	177.1		7.77
	Thur 6/01	319	1994.0	1604.0	1.53	0.10	37.2	175.5		7.80
	Frid 7/01	320	1712.0	1410.0	1.52	0.09	33.0	186.9		7.76
	Sat 8/01	321								
	Sun 9/01	322	1808.0	1504.0	1.48	0.09	33.4	210.2		7.72
	Mon 10/01	323	1936.0	1610.0	1.50	0.10	29.4	180.8		8.03
	Tues 11/01	324	1980.0	1642.0	1.45	0.09	28.0	191.9	7.57	7.85

	Date	Day	MLSS (mg/l)	MLVSS (mg/l)	COD/ VSS	TKN/ VSS	OUR (mg/l/h)	DSVI (ml/g)	pH An	pH Aero
	Wed 12/01	325	1922.0	1542.0	1.53	0.10	31.6	197.7	7.67	7.85
	Thur 13/01	326	1920.0	1606.0	1.52	0.09	29.8	197.9		
	Frid 14/01	327	1968.0	1624.0	1.50	0.09	35.8	203.3		
AVERAGE	***Batch 11/23***		***1931.3***	***1580.4***	***1.48***	***0.10***	***34.5***	***186.8***	***0.00***	***7.81***
Batch 12/24	Sat 15/01	328								
	Sun 16/01	329								
	Mon 17/01	330	1932.0	1604.0	1.29	0.09	30.6	196.7	7.64	7.48
	Tues 18/01	331							7.47	7.67
	Wed 19/01	332	1894.0	1592.0	1.36	0.09	53.5	200.6	7.83	7.73
	Thur 20/01	333	1934.0	1586.0	1.34	0.09	38.2	206.8	7.59	7.70
	Frid 21/01	334	1952.0	1610.0	1.32	0.09	40.0	184.4	7.63	7.73
	Sat 22/01	335								
	Sun 23/01	336	1838.0	1576.0	1.30	0.08	30.5	195.9	7.81	7.99
	Mon 24/01	337	1908.0	1594.0	1.35	0.09	31.5	188.7	7.74	8.20
	Tues 25/01	338	2100.0	1720.0	1.35	0.09	33.6	204.8	7.66	7.90
	Wed 26/01	339	2082.0	1752.0	1.36	0.09	31.5	201.7	7.68	8.19
	Thur 27/01	340	2114.0	1748.0	1.33	0.09	28.1	193.9	7.74	8.15
	Frid 28/01	341								
AVERAGE	***Batch 12/24***		***1972.7***	***1642.4***	***1.33***	***0.09***	***35.3***	***197.1***	***7.68***	***7.87***
Batch 13/25	Sat 29/01	342								
	Sun 30/01	343	2126.0	1768.0	1.36	0.09	25.7	188.1	7.70	8.12
	Mon 31/01	344	2100.0	1704.0	1.49	0.09	23.3	195.2	7.61	7.94
	Tues 01/02	345	2134.0	1782.0	1.36	0.09	27.8	178.1	7.56	8.01
	Wed 02/02	346	2202.0	1826.0	1.36	0.09	26.3	195.3	7.56	7.90
	Thur 03/02	347								
	Frid 04/02	348								
	Sat 05/02	349	2304.0	1934.0	1.26	0.08	26.4	164.9	7.57	8.14
	Sun 06/02	350	2188.0	1784.0	1.38	0.09	38.3	173.7	7.60	7.85
	Mon 07/02	351	2284.0	1864.0	1.38	0.08	33.1	179.5	7.54	7.90
	Tues 08/02	352	2154.0	1748.0	1.44	0.09	32.2	190.3	7.49	7.73
	Wed 09/02	353	2262.0	1838.0	1.36	0.09	37.5	176.8	7.52	7.75
	Thur 10/02	354	2330.0	1888.0	1.29	0.09	32.3	188.8	7.41	7.74
	Frid 11/02	355								
AVERAGE	***Batch 13/25***		***2208.4***	***1813.6***	***1.36***	***0.09***	***30.3***	***183.1***	***7.56***	***7.91***
Batch 14/26	Sat 12/02	356								
	Sun 13/02	357								
	Mon 14/02	358	2004.0	1612.0	1.57	0.09	35.1	179.6	7.63	7.82
	Tues 15/02	359	2070.0	1692.0	1.30	0.09	29.5	188.4	7.65	7.78
	Wed 16/02	360	2000.0	1638.0	1.26	0.09	32.2	205.0	7.63	7.75
	Thur 17/02	361	1984.0	1616.0	1.36	0.09	38.4	201.6	7.57	7.70
	Frid 18/02	362								
	Sat 19/02	363								
	Sun 20/02	364	1966.0	1596.0	1.32	0.09	37.8	193.3	7.74	7.92
	Mon 21/02	365	2110.0	1712.0	1.29	0.09	33.2	208.5	7.57	7.91
	Tues 22/02	366	2112.0	1732.0	1.31	0.09	33.1	222.5	7.55	7.97
	Wed 23/02	367	2204.0	1782.0	1.37	0.09	26.9	208.7	7.55	7.72
	Thur 24/02	368								
	Frid 25/02	369								
AVERAGE	***Batch 14/26***		***2056.3***	***1672.5***	***1.35***	***0.09***	***33.3***	***201.0***	***7.61***	***7.82***
Batch 15/27	Sat 26/02	370								
	Sun 27/02	371	2600.0	2112.0	1.30	0.09	26.9	180.8	7.56	8.05
	Mon 28/02	372	2468.0	1986.0	1.38	0.06	29.3	166.1	7.50	7.77
	Tues 29/02	373	2528.0	2040.0	1.44	0.10	23.6	150.3	7.62	7.88
	Wed 01/03	374	2314.0	1882.0	1.31	0.09	24.4	146.9	7.62	7.95
	Thur 02/03	375	2082.0	1660.0	1.54	0.09	24.0	158.5	7.56	7.90
	Frid 03/03	376								

	Date	Day	MLSS (mg/l)	MLVSS (mg/l)	COD/ VSS	TKN/ VSS	OUR (mg/l/h)	DSVI (ml/g)	pH An	pH Aero
	Sat 04/03	377								
	Sun 05/03	378								
	Mon 06/03	379	2436.0	1950.0	1.36	0.09	27.9	156.0	7.38	7.68
	Tues 07/03	380	2434.0	1964.0	1.52	0.09	31.6	156.1	7.45	7.63
	Wed 08/03	381	2296.0	1834.0	1.48	0.09	30.9	165.5	7.56	7.79
	Thur 09/03	382	3162.0	1880.0	1.50	0.09	30.1	113.9		
AVERAGE	***Batch 15/27***		***2480.0***	***1923.1***	***1.42***	***0.09***	***27.6***	***154.9***	***7.53***	***7.83***
Batch 16/28	Frid 10/03	383								
	Sat 11/03	384								
	Sun 12/03	385	2596.0	2102.0	1.41	0.09	29.1	154.1	7.84	8.05
	Mon 13/03	386								
	Tues 14/03	387	2560.0	2068.0	1.43	0.10	26.0	160.2	7.45	7.85
	Wed 15/03	388	2636.0	2144.0	1.19	0.09	27.8	151.7	7.37	7.69
	Thur 16/03	389	2512.0	2026.0	1.36	0.10	27.0	159.2	7.48	7.79
	Frid 17/03	390								
	Sat 18/03	391								
	Sun 19/03	392	2464.0	1944.0	1.37	0.10	29.5	154.2	7.46	7.78
	Mon 20/03	393	2304.0	1850.0	1.72	0.10	28.2	169.3	7.52	7.82
	Tues 21/03	394	2438.0	1934.0	1.43	0.09	28.5	155.9	7.50	7.72
	Wed 22/03	395	2484.0	1986.0	1.36	0.09	27.9	153.0	7.42	7.71
	Thur 23/03	396								
AVERAGE	***Batch 16/28***		***2499.2***	***2006.7***	***1.40***	***0.09***	***28.0***	***157.2***	***7.51***	***7.80***
Batch 17/29	Frid 24/03	397								
	Sat 25/03	398								
	Sun 26/03	399	2360.0	1842.0	1.50	0.10	26.1	144.1	7.37	8.06
	Mon 27/03	400								
	Tues 28/03	401	2434.0	1894.0	1.35	0.10	26.9	147.9	7.46	7.97
	Wed 29/03	402	2452.0	1910.0	1.60	0.10	26.0	146.8	7.41	7.82
	Thur 30/03	403	2470.0	1940.0	1.44	0.10	27.1	145.7	7.40	8.07
	Frid 31/03	404								
	Sat 01/04	405								
	Sun 02/04	406	2052.0	1588.0	1.51	0.09	24.6	146.2	7.09	7.89
	Mon 03/04	407	2686.0	2094.0	1.38		28.3	134.0	7.39	7.66
AVERAGE	***Batch 17/29***		***2409.0***	***1878.0***	***1.46***	***0.10***	***26.5***	***144.1***	***7.35***	***7.91***
Batch 18/30	Tues 04/04	408								
	Wed 05/04	409	2578.0	1966.0	1.44	0.09	30.7	155.2	7.35	7.62
	Thur 06/04	410	2632.0	2018.0	1.43	0.08	29.1	152.0	7.40	7.71
	Frid 07/04	411	2390.0	1808.0	1.48	0.10	23.5	142.3	7.40	7.67
	Sat 08/04	412	2590.0	1972.0	1.35	0.08	27.5	139.0		
	Sun 09/04	413	2508.0	1910.0	1.43	0.08	26.0	143.5	7.75	8.07
	Mon 10/04	414	2526.0	1934.0	1.29	0.08	30.0	146.5	7.62	8.01
	Tues 11/04	415	2488.0	1888.0	1.32	0.09	30.1	144.7	7.43	7.65
	Wed 12/04	416	2438.0	1862.0	1.59	0.10	29.4	147.7	7.49	7.71
	Thur 13/04	417	2464.0	1878.0	1.35	0.09	29.3	129.9	7.51	7.62
	Frid 14/04	418	2478.0	1866.0	1.46	0.09	30.1	129.1	7.45	7.79
	Sat 15/04	419								
	Sun 16/04	420	2400.0	1834.0	1.56	0.11	24.7	133.3	7.54	7.84
	Mon 17/04	421	2422.0	1868.0	1.47	0.10	26.0	136.3	7.70	8.04
AVERAGE	***Batch 18/30***		***2492.8***	***1900.3***	***1.43***	***0.09***	***28.0***	***141.6***	***6.89***	***7.14***

Batch	Date	Day	delta P An	delta P Ax	delta P Aero	delta P SET	P uptake	P release	Net P	delta NO3 An	delta NO3 Ax	delta NO3 Aero	delta NO3 ST	delta NO3-N An	delta NO3-N Ax	delta NO3-N Aero	delta NO3-N ST	NH4 upt	delta N SET	N2 produc	TKN balance	COD in	OUR T	NO3 for NO3 rdn	NO for NO3 rdn	BOD	NO3 Denit	NO3 Denit	COD eff	COD waste	COD T out	COD balance
Batch 1/13	Sat 07/08	167																																
	Sun 08/08	168																																
	Mon 09/08	169																																
	Tues 10/08	170	22.8	4.4	-33.6	-6.4	-40.3	27.0	0.0	0.1	-7.6	14.3	-6.1	5.9	-41.5	58.8	-19.2	79.5	-22.3	71.4	101.4	15462.9	6391.2	979.7	5357.0	54.6	468.2	3303.6	1310.7	4997.1	10134.4	65.6
	Wed 11/08	171	9.5	-3.9	-19.6	-0.7	-24.2	8.5	14.7	-3.5	-1.2	10.7	0.8	-5.4	-25.6	49.3	-0.2	58.4	0.6	35.7	106.2	19005.4		785.8	4508.1		190.0	1784.3	2539.5	5324.8	4514.7	23.8
	Thur12/08	172	14.0	-2.5	-22.4	-0.7	-25.6	14.0	11.6	-0.0	-6.4	9.3	-1.0	-1.4	-27.1	35.6	6.4	69.4	5.4	34.8	74.7	15319.0	6336.0	635.2	3848.6	1852.2	251.4	1625.2	983.0	3768.3	8480.2	55.4
	Frid 13/08	173																																
	Sat 14/08	174	11.9	4.9	-28.0	4.2	-28.0	21.0	7.0	-0.0	-2.9	3.2	1.1	-0.0	-8.1	7.8	5.5	51.2	6.6	11.1	87.5	14663.7	8902.4	301.2	1189.4	8411.8	101.2	465.8	1802.2	5618.3	16587.4	113.2
	Sun 15/08	175	14.7	22.1	-39.3	-0.7	-40.0	36.6	3.2	-0.0	-5.1	6.5	0.8	-0.0	-14.9	16.0	6.4	40.3	7.2	20.1	87.7	14082.7	7847.8	497.7	2052.1	5297.8	178.3	855.1	1287.3	5682.3	13278.8	94.4
	Mon 16/08	176	15.4	-12.3	-14.0	-0.7	-27.0	15.4	11.6	-0.4	-0.4	1.0	1.3	-1.5	-31.0	51.0	-7.9	59.8	-8.6	39.9	92.0	13817.4		157.2	4657.5		29.4	2310.1	899.4	5641.4	4095.6	29.4
	Tues 17/08	177	17.3	-1.3	-31.3	0.0	-32.6	17.3	15.4	0.0	-2.3	3.5	-0.5	-0.1	-43.5	55.7	5.1	69.4	4.6	45.6	95.2	16924.3	8484.0	243.0	5550.7	2690.3	94.7	2492.4	1144.6	5518.8	11940.8	70.6
	Wed 18/08	178	10.5	4.2	-28.7	-2.0	-30.7	14.8	15.9	0.0	-2.2	3.4	-0.7	-0.3	-48.3	66.3	1.8	64.4	1.2	51.7	110.6	16352.0	8930.4	235.3	6221.8	2473.3	96.0	2838.5	1226.4	5477.9	12112.1	74.1
	Thur 19/08	179	18.1	-8.5	-20.9	0.0	-29.4	18.1	13.3	-0.0	-1.5	2.5	-0.8	-0.3	-47.0	61.5	3.8	73.9	3.2	48.8	84.3	17087.8	9192.0	172.3	5964.8	3054.9	69.9	2706.4	1635.2	5886.7	13353.1	78.1
	Frid 20/08	180	17.4	-2.8	-26.1	-2.8	-31.3	17.4	14.0	-0.0	-1.3	2.4	-0.7	-0.1	-43.5	57.3	2.3	68.3	1.6	45.0	93.6	15289.1	10068.0	165.8	5443.4	4458.8	68.3	2495.8	1287.3	5355.3	13645.5	89.2
	Sat 21/08	181																																
	Sun 22/08	182																																
	Mon 23/08	183	12.9	-2.3	-22.2	1.3	-24.5	14.2	10.3	-0.0	-1.2	2.6	-1.0	-0.4	-46.5	64.4	-1.3	73.6	-2.3	50.5	94.7	15985.6	10708.9	180.0	5686.3	4640.8	78.5	2754.6	741.6	4661.8	13076.9	81.8
	Tues 24/08	184																																
	Wed 25/08	185																																
	Thur 26/08	186																																
AVERAGE	*Batch 1/13*		*14.7*	*0.2*	*-26.0*	*-0.8*	*-28.8*	*15.0*	*11.6*	*-0.4*	*-2.9*	*5.4*	*-0.6*	*-0.3*	*-34.4*	*47.8*	*0.5*	*64.4*	*-0.1*	*38.0*	*87.9*	*15417.3*	*7785.6*	*370.7*	*4394.4*	*3020.7*	*132.0*	*1984.4*	*1347.0*	*5302.6*	*11788.9*	*74.5*
Batch 2/14	Frid 27/08	187																																
	Sat 28/08	188																																
	Sun 29/08	189	25.2	-0.7	-42.9	-0.7	-44.4	25.2	19.2	-0.0	-0.8	1.2	0.0	-2.0	-20.0	32.7	-0.5	61.5	-0.5	23.4	42.9	13431.2	15682.7	82.0	2988.2	12584.5	27.8	1293.2	1318.4	5273.8	20507.6	152.7
	Mon 30/08	190	20.4	21.5	-82.2	0.0	-82.2	41.8	20.4	-0.0	-1.3	2.5	-1.0	-1.6	-18.9	30.2	-4.7	65.9	-5.7	25.5	61.7	14008.0	14146.4	173.8	2757.8	11214.9	78.5	1329.2	947.6	2636.6	16206.9	115.7
	Tues 31/08	191																																
	Wed 01/09	192																																
	Thur 02/09	193																																
	Frid 03/09	194																																
	Sat 04/09	195																																
	Sun 05/09	196																																
	Mon 06/09	197	25.2	-9.6	-35.5	-1.5	-46.6	25.2	21.5	-0.0	-1.1	1.8	-0.4	-0.7	-42.1	66.3	-11.0	57.3	-11.4	55.4	118.4	14281.9	7898.4	131.1	6060.7	1706.5	52.3	3084.1	1067.0	5581.4	11491.4	80.5
	Tues 07/09	198	21.1	-0.7	-41.5	0.0	-42.2	21.1	21.1	-0.0	-1.1	1.9	-0.4	-1.5	-46.0	71.7	-8.3	42.8	-8.7	57.3	153.6	13625.3	7176.0	131.1	6557.6	487.3	52.3	3192.9	1149.1	4842.7	9724.3	71.4
	Wed 08/09	199	17.0	-4.4	-23.7	-5.9	-34.1	17.0	17.0	-0.0	-1.4	2.6	-1.0	-1.7	-31.7	46.3	2.8	63.0	1.6	34.8	88.2	13953.6	6057.6	180.3	4467.8	1409.5	60.1	1910.7	1641.6	4876.8	9720.4	69.7
	Thur 09/09	200	4.8	-3.3	-11.8	-3.7	-16.9	4.8	14.1	-0.1	-1.1	1.8	-0.2	-3.8	-40.3	67.2	-3.3	37.2	-3.5	48.8	160.7	12968.6	5260.6	124.6	8144.0	-1007.8	45.8	2714.1	779.8	4309.2	8841.1	62.8
	Frid 10/09	201																																
	Sat 11/09	202																																
	Sun 12/09	203																																
AVERAGE	*Batch 2/14*		*18.9*	*6.4*	*-38.3*	*-2.0*	*-38.2*	*19.4*	*18.9*	*-0.0*	*-1.1*	*2.0*	*-0.5*	*-1.9*	*-32.8*	*52.4*	*-4.2*	*62.2*	*-4.7*	*40.6*	*96.6*	*13711.4*	*9367.0*	*137.1*	*4789.6*	*4440.2*	*56.1*	*2229.4*	*1150.6*	*5464.5*	*13340.8*	*97.3*
Batch 3/15	Mon 13/09	204																																
	Tues 14/09	205																																
	Wed 15/09	206																																
	Thur 16/09	207	16.5	-5.3	-24.0	4.2	-29.3	20.7	8.5	-0.1	-1.7	2.7	-0.4	-2.7	-39.8	55.0	8.1	69.2	7.7	44.0	97.7	13735.7	6345.6	184.8	5770.9	389.9	72.4	2417.2	1349.0	2984.2	7212.7	52.6
	Frid 17/09	208																																
	Sat 18/09	209																																
	Sun 19/09	210																																
	Mon 20/09	211																																
	Tues 21/09	212	5.6	-3.5	-19.7	-4.2	-27.5	5.6	21.9	-0.2	-0.8	2.1	-0.8	-5.9	-33.9	60.5	2.1	67.6	1.3	40.8	98.4	15661.4	7059.2	145.2	5721.5	1192.5	59.2	2277.1	940.2	4701.2	9170.2	67.8
	Wed 22/09	213	8.4	-10.8	-14.1	-4.2	-28.9	8.4	20.5	-0.1	-0.6	1.6	-0.6	-5.4	-35.6	60.7	3.2	66.6	2.6	41.7	100.6	13769.4	7692.0	112.2	5636.2	1743.7	44.4	2346.0	1026.0	5335.2	10495.3	78.1
	Thur 23/09	214																																
	Frid 24/09	215																																
	Sat 25/09	216																																
	Sun 26/09	217																																
	Mon 27/09	218																																
	Tues 28/09	219																																
AVERAGE	*Batch 3/15*		*10.2*	*-6.5*	*-19.3*	*-1.4*	*-27.1*	*10.2*	*17.0*	*-0.1*	*-1.0*	*2.1*	*-0.6*	*-4.7*	*-36.4*	*58.8*	*4.4*	*68.1*	*3.9*	*42.2*	*98.9*	*14482.2*	*7032.3*	*147.4*	*5776.2*	*1108.7*	*58.7*	*2346.8*	*1106.1*	*4340.2*	*8969.4*	*62.0*
Batch 4/16	Wed 29/09	220	8.8	-5.2	-4.6	-1.2	-11.0	8.8	4.2	-0.1	-7.3	8.9	1.9	-2.9	-29.3	46.5	1.1	72.4	3.0	39.7	88.6	13543.2	8443.2	737.7	4350.8	3354.9	253.5	1844.0	2175.1	4227.1	11854.6	87.6
	Thur 30/09	221	10.9	-0.6	-22.4	3.9	-23.0	14.7	8.2	-0.1	-3.2	5.2	-0.6	-0.7	-35.2	48.2	1.3	64.7	0.5	39.2	88.0	15020.6	0.0	354.5	4527.2	-4881.7	141.0	2051.4	1231.2	3980.9	2522.7	16.8
	Frid 1/10	222																																
	Sat 2/10	223																																
	Sun 3/10	224	13.0	5.6	-35.5	5.6	-35.5	24.4	11.1	-0.0	-1.6	2.7	-0.8	-0.8	-36.6	49.7	2.9	53.6	2.2	39.2	103.2	14336.0	8985.8	182.6	4805.5	3997.5	78.8	2148.9	1024.0	6021.1	13266.2	92.5
	Mon 4/10	225																																
	Tues 5/10	226	21.1	6.8	-43.2	-1.9	-45.1	27.9	17.3	-0.1	-1.5	2.5	-0.4	-0.5	-38.3	52.8	0.2	64.7	-0.2	40.8	90.6	15728.6	9132.0	171.9	4823.5	4136.8	67.8	2221.2	1146.9	5611.5	13184.0	83.8
	Wed 6/10	227	23.9	-4.1	-33.3	-0.6	-38.1	23.9	14.2	-0.1	-1.1	2.1	-0.5	-0.3	-33.8	46.9	-1.1	62.4	-1.7	38.9	85.7	14663.7	8714.8	140.8	4287.2	4286.8	57.3	2014.5	778.2	5652.5	12789.2	87.2
	Thur 7/10	228	39.6	28.4	-78.1	-0.6	-78.9	66.0	10.9	-0.1	-0.9	1.9	-0.6	-0.7	-33.3	47.2	-1.0	60.3	-1.7	36.6	87.7	14581.6	8733.6	133.4	4309.6	4290.4	55.4	2001.7	1024.0	5652.5	13024.0	89.3
	Frid 8/10	229																																
	Sat 9/10	230																																
	Sun 10/10	231																																

Batch	Date	Day	PAO delta P An	AerT	Aero	SST	P uptake	P release	P removal	delta NO2 An	Ax	Aero	ST	delta NO3 An	Ax	Aero	ST	Nitrif cap	delta N SST	N2 produc	TKN balance	COD in	OUR T	NO3 rdn	NO for NO3 rdn	MOx	NO2 Denit	NOx Denit	COD rdf	COD waste	COD out	COD balance
			mgP/l							mgN/l				mgN/l				mgN/l	mgN/l	mgN/l	%	mgCOD/d	mgO/d	mgO/d	mgO/d	mgO/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	%
	Mon 11/10	232																														
AVERAGE	Batch 4/16		19.2	8.2	-38.2	0.8	-38.2	26.2	11.0	-0.1	-2.8	3.9	-0.2	-1.0	-34.4	46.5	0.6	63.1	0.4	35.1	89.3	14845.7	8801.6	265.3	4484.7	4051.8	97.9	2029.2	1229.9	5190.9	12596.8	88.0
Batch 5/17	Tues 12/10	233																														
	Wed 13/10	234	16.2	1.4	-33.3	3.9	-33.3	21.5	11.8	-0.0	-0.4	0.8	-0.2	0.0	-28.6	35.4	0.2	43.0	0.0	27.0	81.1	12959.5	7975.2	53.1	3250.9	4671.3	19.8	1523.9	1057.9	4937.0	12209.9	94.2
	Thur 14/10	235	24.7	-2.5	-39.4	0.8	-42.0	25.5	16.4	-0.0	-0.4	0.8	-0.2	-0.3	-28.7	39.1	-4.0	44.8	-4.1	31.5	84.0	14105.6	8097.6	53.1	3570.5	4474.0	19.8	1767.6	484.9	5025.1	11771.4	83.5
	Frid 15/10	236																														
	Sat 16/10	237																														
	Sun 17/10	238	25.1	-2.5	-29.4	-4.3	-36.2	25.1	11.1	-0.0	-0.0	0.2	0.0	0.3	-28.8	38.0	-0.8	40.0	-0.8	27.7	95.8	12198.1	7306.0	15.2	3288.2	4006.8	1.9	1581.4	969.8	4452.1	11011.8	90.6
	Mon 18/10	239																														
	Tues 19/10	240	29.8	-1.9	-43.3	1.5	-45.2	31.3	13.9	0.1	-0.6	0.9	-0.3	-0.4	-25.2	38.0	-1.6	44.9	-2.1	28.2	88.6	14017.4	7365.6	60.7	3288.4	4018.6	28.3	1568.2	705.3	5113.3	11431.7	81.6
	Wed 20/10	241	32.9	1.5	-48.4	-4.8	-51.0	34.4	18.6	-0.0	-0.2	0.5	-0.2	-0.3	-25.0	34.1	0.2	41.0	0.0	25.5	90.9	15014.4	6816.0	34.1	3129.8	3652.3	13.2	1447.8	816.0	5222.4	11151.5	74.3
	Tues 21/10	242	14.8	-5.8	-28.5	4.1	-34.3	18.7	15.6	0.1	-0.3	0.4	0.1	-0.0	-17.1	19.6	5.1	41.9	5.2	17.4	74.3	13708.6	6748.8	33.5	2274.8	4440.4	11.7	979.8	979.2	5059.2	11470.4	83.7
	Frid 22/10	243																														
	Sat 23/10	244																														
	Sun 24/10	245	-3.7	3.1	-2.7	-3.4	-6.1	-0.7	6.8	0.1	-0.1	0.3	-0.2	-0.2	-20.9	27.1	2.3	44.6	2.2	21.0	78.1	12974.4	7480.6	18.6	2688.3	4773.9	7.9	1205.9	1428.0	5385.6	12801.2	98.7
	Mon 25/10	246	12.2	4.1	-23.1	4.6	-23.1	21.1	2.0	-0.7	2.3	-0.9	-0.4	-0.5	-22.2	29.5	2.3	47.0	1.9	21.0	78.1	13137.6	7778.4	0.0	2907.5	4870.9	37.2	1296.1	571.2	4692.0	11467.4	87.3
AVERAGE	Batch 5/17		22.4	-0.8	-34.8	0.9	-35.6	23.2	12.4	-0.1	0.0	0.4	-0.2	-0.2	-23.8	32.1	0.4	43.4	0.3	24.0	84.6	13510.5	7446.3	25.1	2974.6	4448.4	7.7	1371.8	876.5	4985.8	11688.2	88.5
Batch 6/18	Tues 26/10	247																														
	Wed 27/10	248	21.4	2.4	-32.6	0.7	-32.6	24.5	8.2	0.0	-0.3	0.5	0.0	-0.1	-22.1	28.7	1.8	45.6	1.8	22.5	78.3	13953.6	6715.2	33.5	2786.1	3695.6	9.4	1270.2	1142.4	4528.8	10845.3	77.7
	Tues 28/10	249	20.4	2.4	-32.6	0.7	-32.6	23.4	9.2	-0.0	-0.4	0.9	-0.2	-0.3	-24.5	34.6	-1.6	48.7	-1.9	27.0	81.4	18604.6	7521.6	59.6	3158.4	4303.6	22.3	1509.1	652.8	4814.4	11302.2	60.7
	Frid 29/10	250	18.3	2.0	-34.0	0.7	-34.0	21.1	12.9	0.0	-0.2	0.4	-0.1	0.0	-25.4	33.6	0.5	46.5	0.4	25.8	83.4	17217.6	7465.6	29.5	3114.1	4342.0	10.1	1450.2	1632.0	5630.4	13064.7	78.9
	Sat 30/10	251																														
	Sun 31/10	252	23.0	6.1	-46.2	4.1	-46.2	33.2	13.0	-0.0	-0.3	0.5	0.0	-0.2	-25.0	36.4	-3.7	44.8	-3.7	29.2	89.2	16238.4	7910.4	33.2	3324.4	4552.8	11.0	1649.5	1224.0	5304.0	12741.3	78.8
	Mon 1/11	253																														
	Tues 2/11	254	24.3	-5.8	-34.0	0.0	-39.6	24.3	15.5	-0.0	-0.2	0.4	0.0	-0.5	-22.5	32.4	-1.6	48.7	-1.8	24.8	78.4	15340.6	7404.0	29.5	2965.7	4408.6	9.2	1404.0	930.4	5222.4	11962.9	78.1
	Wed 3/11	255	20.0	0.0	-38.1	2.7	-38.1	22.8	15.3	0.0	-0.5	0.8	-0.1	-0.5	-22.3	32.1	-1.5	44.9	-1.6	24.8	82.7	15422.4	7668.0	51.6	2936.2	4680.2	19.9	1367.1	693.6	5426.4	12207.2	79.2
	Thur 4/10	256	27.5	3.1	-47.6	0.0	-47.6	30.6	17.0	-0.0	-0.2	0.3	0.0	-0.2	-29.8	38.0	-2.6		-2.6	29.8	88.3	18220.2	7603.2	22.1	3473.1	4107.9	6.4	1693.1	778.2	5201.9	11787.7	72.7
	Frid 5/11	257	21.4	4.1	-37.2	0.7	-37.2	26.2	11.0	0.0	-0.5	0.6	-0.1	-0.0	-21.0	28.4	-0.3	47.0	-0.4	21.9	71.6	14745.6	7382.4	51.7	2595.0	4735.7	20.6	1221.6	1142.6	4546.6	11667.2	79.1
	Sat 6/11	258																														
	Sun 7/11	259	18.8	11.0	-35.9	0.0	-35.9	27.8	8.3	-0.0	-1.0	1.7	-0.5	-0.1	-19.2	26.9	-1.3	42.1	-1.7	22.1	78.9	13434.9	7392.0	118.4	2456.8	4818.8	50.1	1178.1	814.4	4423.7	11083.1	82.5
	Mon 8/11	260								0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0															
AVERAGE	Batch 6/18		21.4	2.8	-37.6	1.1	-37.6	25.3	12.2	-0.0	-0.4	0.7	-0.1	-0.2	-23.2	32.3	-1.2	45.8	-1.2	25.0	81.9	15686.5	7453.6	47.7	2958.2	4449.7	17.5	1403.6	994.0	5011.0	11875.7	75.7
Batch 7/19	Tues 9/11	261																														
	Wed 10/11	262	26.9	-4.1	-31.7	-0.7	-36.6	26.9	9.7	-0.2	0.7	0.0	-0.4	-0.5	-23.9	34.9	-2.4	56.8	-2.9	26.7	71.9	13782.6	7814.4	2.9	3192.5	4618.9	20.3	1531.1	1228.8	5324.8	12723.9	92.5
	Thur 11/11	263	18.3	7.9	-29.0	-5.5	-34.5	26.2	8.3	-0.0	-3.3	8.1	-2.3	-0.1	-23.1	26.9	8.5	72.1	4.2	26.5	60.8	17121.3	7845.6	417.3	3055.8	4372.5	192.5	1327.5	778.2	3845.4	10316.2	60.3
	Frid 12/11	264																														
	Sat 13/11	265																														
	Sun 14/11	266	23.1	-2.4	-24.8	6.2	-27.2	29.3	-2.1	-0.2	0.9	-0.3	-0.2	-1.0	-29.9	43.2	-0.7	59.5	-1.0	31.1	80.8	11519.0	6984.0	0.0	3850.1	3033.9	14.8	1608.5	649.0	4216.2	9772.4	84.4
	Mon 15/11	267	18.3	-5.2	-23.4	-4.1	-32.8	18.3	14.5	-0.2	0.7	0.1	-0.4	-1.5	-32.7	47.6	0.4	62.6	0.0	33.7	87.4	15980.6	7684.8	5.9	4391.9	3287.1	23.0	1856.0	567.5	3731.5	9565.4	59.9
	Tues 16/11	268	15.2	19.3	-41.4	-1.4	-42.8	34.5	8.3	-0.2	0.6	0.2	-0.4	-1.4	-34.7	47.7	4.0	63.8	3.6	35.7	86.5	15575.0	8126.4	13.2	4720.6	3392.6	20.1	2065.1	1216.8	4339.9	11034.5	70.8
	Wed 17/11	269	17.8	15.5	-41.4	-0.7	-42.1	33.4	8.6	-0.2	0.3	0.4	-0.4	-0.8	-36.7	48.5	3.2	84.1	2.9	37.1	86.7	16710.7	8371.2	29.3	4732.3	3609.7	19.3	2132.4	892.3	4788.1	11439.8	68.6
	Thur 18/11	270	15.2	14.8	-38.6	0.7	-38.6	31.7	8.9	-0.2	0.0	0.9	-0.6	-0.2	-31.9	41.3	2.8	58.8	2.2	32.2	83.6	15698.5	7785.0	60.0	4027.6	3700.4	25.4	1834.4	973.4	3812.6	10346.2	65.1
	Frid 19/11	271	20.0	2.1	-34.5	-0.7	-35.2	22.1	13.1	-0.2	0.2	0.6	-0.4	-0.2	-31.2	41.3	1.8	67.6	1.4	31.5	73.3	19631.0	7336.8	41.0	3840.0	3355.8	20.3	1800.2	1135.7	3488.2	9600.1	48.9
AVERAGE	Batch 7/19		18.5	8.0	-33.1	-0.8	-33.9	25.5	8.4	-0.2	0.0	1.0	-0.6	-0.7	-30.5	41.4	1.9	65.7	1.3	31.4	75.4	15775.0	7743.9	69.0	3985.1	3709.8	27.9	1784.0	930.3	4188.4	10620.2	67.3
Batch 8/20	Sat 20/11	272																														
	Sun 21/11	273	11.8	4.5	-30.6	0.7	-30.6	17.1	13.6	0.2	-0.4	0.8	-0.3	0.2	-22.9	30.1	1.1	49.0	0.8	23.3	76.2	16709.4	6962.4	39.1	2850.0	4073.4	24.7	1307.1	868.6	4177.4	10451.1	62.6
	Mon 22/11	274																														
	Tues 23/11	275	10.8	10.4	-32.0	-4.9	-36.9	21.2	15.7	0.0	-0.3	0.7	-0.3	-0.0	-24.8	32.5	1.6	64.7	1.2	25.1	64.9	16709.4	7588.8	45.1	3108.8	4434.9	21.7	1421.9	1075.4	4921.8	11875.7	71.1
	Wed 24/11	276	19.8	-2.1	-32.0	3.5	-34.1	23.3	10.8	-0.0	-0.3	0.8	-0.3	-0.1	-22.6	29.8	1.1	53.5	0.6	23.0	70.0	16295.6	6007.2	43.6	2825.2	3138.4	18.9	1298.7	868.6	4506.2	9632.6	60.3
	Thur 25/11	277	16.4	4.2	-33.4	-1.4	-34.8	20.5	14.3	0.0	-0.3	0.8	-0.2	-0.3	-21.5	28.1	2.3	63.3	2.0	22.1	61.8	18363.8	7401.6	40.6	2777.5	4583.5	16.7	1248.9	951.3	4301.4	11099.9	60.4
	Frid 26/11	278	17.1	4.9	-34.6	-0.7	-35.5	21.9	13.6	0.0	-0.3	0.6	-0.2	-0.1	-24.7	31.6	2.6	38.6	2.4	25.1	94.9	14641.4	6451.2	44.4	3127.9	3279.0	18.0	1419.4	1447.8	4177.4	10342.3	70.6
	Sat 27/11	279																														
	Sun 28/11	280	24.4	-0.7	-37.6	2.1	-38.3	26.4	11.8	0.1	-0.4	0.8	-0.1	-0.1	-23.8	31.1	1.7	49.7	1.8	24.3	77.6	15834.1	7027.2	39.8	3008.0	3981.3	18.8	1368.1	868.6	5500.9	11737.7	76.1
	Mon 29/11	281																														
	Tues 30/11	282	22.3	2.1	-33.4	0.0	-33.4	24.4	9.0	0.1	-0.5	0.8	0.0	-0.0	-24.1	33.8	-1.8	46.2	-1.6	26.2	82.7	15687.9	6398.0	42.3	3071.0	3282.7	18.9	1488.8	1287.3	5028.2	11083.7	70.6
	Wed 1/12	283	19.5	-0.3	-30.8	0.7	-31.0	20.2	10.8	0.0	-0.3	0.5	-0.1	-0.0	-25.7	35.5	-1.2	44.4	-1.3	27.3	88.0	14308.0	7588.8	34.1	3242.3	4312.4	11.8	1542.5	1308.2	4660.3	11835.1	82.7
	Thur 2/12	284	23.0	-0.0	-34.8	0.7	-34.8	23.7	11.1	0.1	-0.5	0.7	-0.1	-0.1	-24.7	34.0	-1.1	41.1	-1.2	26.3	90.8	12918.1	7802.4	46.7	3107.8	4648.0	19.9	1478.3	1226.4	4496.8	11867.4	91.9
AVERAGE	Batch 8/20		18.3	2.8	-33.3	0.1	-33.3	21.0	12.3	0.1	-0.4	0.6	-0.2	-0.1	-23.9	31.8	0.7	49.9	0.5	24.2	76.5	15697.6	7025.1	41.7	2973.8	4009.5	18.7	1368.6	1096.0	4641.4	11136.1	70.9
Batch 9/21	Frid 3/12	285																														
	Sat 4/12	286																														
	Sun 5/12	287																														
	Mon 6/12	288	21.8	-1.4	-28.7	-0.7	-30.7	21.8	8.9	0.1	-0.3	0.3	0.0	0.1	-20.0	23.9	4.8	38.4	4.8	20.3	86.4	13899.2	7936.8	23.7	2618.9	5294.2	10.3	1144.3	1062.9	4987.4	12499.1	89.9
	Tues 7/11	289	19.5	0.3	-30.0	-0.7	-30.7	19.6	10.8	0.0	-0.2	0.4	-0.1	0.0	-21.2	27.5	1.7	38.3	1.6	21.4	85.3	13899.2	7620.0	28.9	2674.3	4916.8	11.3	1212.9	1308.2	5110.0	12559.2	90.4
	Wed 8/12	290	19.1	0.0	-27.3	-2.7	-30.0	19.1	10.9	0.0	-0.2	0.4	-0.1	-0.0	-18.7	22.3	4.7	41.6	4.6	19.0	78.9	14798.6	7892.0	28.9	2465.7	5187.4	13.1	1072.9	899.4	5518.8	12701.5	85.8
	Thur 9/12	291	18.1	-1.0	-32.8	0.7	-33.8	18.8	15.0	0.0	-0.2	0.3	-0.1	0.0	-22.1	30.0	-0.4	40.3	-0.5	22.8	85.8	13814.2	7490.4	23.7	2741.3	4725.4	10.1	1287.3	744.5	4797.6	11565.0	83.7
	Frid 10/12	292																														
	Sat 11/12	293																														
	Sun 12/12	294	19.8	-1.7	-28.7	2.7	-30.4	22.5	7.6	0.1	-0.2	0.3	-0.1	0.1	-21.5	28.4	0.7	39.8	0.8	21.7	85.6	13731.5	7274.4	18.5	2681.9	4584.0	10.1	1229.4	1075.4	4921.8	11830.7	86.2

Batch	Date	Day	delta P An	delta P Ax	delta P Aero	delta P SET	P uptake	P release	P rel/up	delta NO2 An	delta NO2 Ax	delta NO2 Aero	delta NO2 ST	delta NO3 An	delta NO3 AX	delta NO3 Aero	delta NO3 ST	Max cap. Nc mgN/l	delta N SET mgN/l	N2 produc. mgN/l	TKN balance	COD in mgCOD/d	OUR T mgO/d	NO for NO2 nitr mgO/d	NO for NO3 nitr mgO/d	NOc mgO/d	NO2 Denit mgCOD/d	NO3 Denit mgCOD/d	COD eff mgCOD/d	COD waste mgCOD/d	COD out mgCOD/d	COD balance
	Mon 13/12	295																														
	Tues 14/12	296	20.7	-2.1	-28.0	2.4	-30.1	23.1	7.0	0.0	-0.2	0.4	-0.1	-0.2	-20.9	28.6	-0.2	45.1	-0.3	21.6	76.9	15718.6	7768.8	29.2	2610.5	5128.0	11.3	1215.8	1530.3	5128.6	13015.1	82.6
AVERAGE	Batch 8/21		19.8	-1.0	-29.2	0.3	-30.2	20.1	10.1	0.1	-0.2	0.4	-0.1	0.0	-20.7	28.8	1.9	40.7	1.8	21.0	82.6	14309.9	7630.4	25.5	2619.7	4985.2	11.1	1186.1	1103.4	5077.4	12363.2	88.4
Batch 10/22	Wed 15/12	297																														
	Thur 16/12	298																														
	Frid 17/12	299																														
	Sat 18/12	300																														
	Sun 19/12	301	13.9	-0.3	-24.8	1.9	-25.1	15.8	9.3	-0.2	0.8	0.1	-0.6	0.4	-29.6	38.2	2.3	56.6	1.7	28.8	80.2	14641.4	8191.2	3.7	3702.0	4485.4	27.4	1691.4	1075.4	4921.8	12201.4	83.3
	Mon 20/12	302	15.2	-2.8	-22.3	-0.6	-25.7	15.2	10.5	-1.1	5.1	-3.2	-0.7	-0.9	-28.5	38.6	1.9	58.0	1.3	25.4	78.0	14641.4	7704.0	0.0	3798.7	3905.3	59.8	1681.9	827.2	5004.8	11478.8	78.4
	Tues 21/12	303	13.0	-1.2	-18.6	-1.8	-21.7	13.0	8.7	-0.9	4.7	-2.9	-0.8	-0.8	-28.6	38.3	3.7	56.1	2.9	25.7	78.4	14641.4	7296.0	0.0	3836.6	3459.4	58.1	1684.4	1323.5	4839.1	11384.6	77.6
	Wed 22/12	304	18.3	-11.5	-19.8	3.1	-31.3	21.4	8.9	-0.6	2.9	-1.8	-0.3	-0.0	-35.2	47.2	0.3	56.1	0.0	33.0	88.1	14972.3	9290.4	0.0	4342.2	4948.2	31.7	2016.0	1075.4	4873.7	12744.9	85.1
	Thur 23/12	305	15.5	-5.8	-19.8	0.0	-25.4	15.5	9.9	-0.7	3.4	-1.9	-0.7	-0.7	-28.9	39.2	2.1	55.5	1.5	26.9	79.6	15055.0	9254.4	0.0	3775.6	5478.6	47.7	1690.0	1489.0	4715.0	13420.5	89.1
	Frid 24/12	306																														
	Sat 25/12	307																														
	Sun 26/12	308	8.3	-2.8	-21.1	6.2	-23.8	15.5	8.4	-0.2	0.3	0.1	0.4	-0.5	-28.3	37.0	3.3	53.7	3.7	28.7	84.6	13235.2	9578.0	37.3	3675.1	5863.5	6.9	1644.5	1240.8	5211.4	13967.1	105.5
	Mon 27/12	309																														
	Tues 28/12	310																														
	Wed 29/12	311	10.6	-3.4	-14.9	-3.1	-21.4	10.8	10.5	-0.5	2.7	-1.2	-0.8	-0.2	-25.2	34.4	1.2	55.9	0.4	23.3	72.4	14227.8	8083.2	0.0	3254.3	4826.9	48.3	1457.1	827.2	4797.8	11957.3	84.0
	Thur 30/12	312	11.1	-8.8	-13.8	-0.6	-21.1	11.1	9.9	-1.0	4.6	-2.7	-0.8	-1.7	-20.9	32.2	0.9	58.7	0.1	19.0	64.8	13568.1	8757.6	0.0	3017.8	5739.8	59.6	1292.6	892.6	4425.5	12510.1	92.2
AVERAGE	Batch 10/22		13.4	-4.3	-19.4	0.6	-23.7	14.0	9.6	-0.7	3.1	-1.7	-0.5	-0.6	-28.3	38.2	2.0	55.8	1.4	26.3	78.3	14372.6	8519.1	0.0	3675.1	4843.8	40.3	1642.0	1105.4	4833.8	12456.1	86.7
Batch 11/23	Frid 31/12	313																														
	Sat 1/01	314																														
	Sun 2/01	315																														
	Mon 3/01	316	3.1	4.3	-14.9	0.0	-14.9	7.4	7.4	-2.0	1.2	3.0	1.4	-6.4	-23.1	48.3	0.7	80.7	2.1	30.3	76.9	16295.8	10464.0	302.2	4486.8	5875.0	67.0	1689.8	1489.0	5045.9	13968.6	85.7
	Tues 4/01	317	7.4	-3.7	-11.1	-0.6	-15.5	7.4	8.1	-0.7	2.7	-1.6	0.5	-2.9	-31.6	43.1	10.8	53.9	11.4	32.5	100.3	16295.8	9808.4	37.3	4926.8	4842.3	25.0	1973.3	1489.0	4873.7	13003.2	79.8
	Wed 5/01	318	9.0	-4.0	-8.7	-3.7	-16.4	9.0	7.4	-0.3	1.0	0.1	-0.6	-0.8	-28.1	37.8	3.2	55.1	2.6	28.3	83.1	15551.4	8944.8	7.5	3750.4	5187.0	31.1	1654.8	1778.5	4508.2	13159.4	84.6
	Thur 6/01	319	15.5	-7.4	-12.4	-1.2	-21.1	15.5	5.6	-0.3	0.7	0.5	-0.7	-0.7	-30.2	43.7	-2.0	55.4	-2.7	33.3	87.2	15340.8	8937.6	33.6	3997.7	4906.3	34.7	1684.8	1428.0	5018.4	13272.1	86.6
	Frid 7/01	320	10.8	-9.0	-11.1	0.0	-20.1	10.8	9.3	-0.8	3.3	-1.6	-0.7	-1.4	-28.6	41.3	1.0	59.8	0.3	27.4	76.3	15259.2	7917.6	0.0	3868.3	4051.3	50.8	1712.2	1101.6	4365.6	11281.5	73.9
	Sat 8/01	321																														
	Sun 9/01	322	9.5	-4.6	-13.6	0.0	-18.2	9.5	8.6	-0.6	2.5	-1.0	-0.8	-0.7	-30.0	39.9	4.1	59.4	3.3	28.8	78.8	13872.0	8016.0	0.0	4025.4	3990.6	49.3	1754.9	530.4	4488.0	10813.3	78.0
	Mon 10/01	323	10.2	-4.0	-13.6	-1.2	-16.8	10.2	6.6	-0.8	2.6	-0.9	-1.0	-0.8	-31.7	44.5	0.8	61.0	-0.2	30.6	79.7	15504.0	7058.4	0.0	4136.4	2922.0	55.0	1659.2	856.8	4898.0	10589.0	68.3
	Tues 11/01	324	9.9	-6.2	-12.3	1.2	-18.5	11.1	7.4	-0.6	2.8	-1.2	-0.7	-0.6	-33.3	46.6	-0.2	58.6	-0.9	32.7	84.0	16075.2	6720.0	0.0	4259.1	2460.9	43.9	1948.7	856.8	4655.2	10165.5	63.2
	Wed 12/01	325	12.3	-5.5	-11.1	-0.6	-17.2	12.3	4.9	-0.2	0.5	0.2	-0.4	-0.0	-33.6	44.1	1.9	59.8	1.5	33.3	83.8	15504.0	7584.0	11.1	4205.7	3367.2	16.6	1924.7	938.4	4773.6	11022.6	71.1
	Thur 13/01	326	8.9	-1.2	-17.2	3.7	-18.5	12.6	5.8	-0.1	-0.3	1.4	-0.9	0.1	-32.5	43.3	0.3	54.8	-0.7	33.5	88.1	13569.8	7161.6	96.4	3978.6	3085.5	45.3	1859.1	1101.6	4936.8	11028.3	81.3
	Frid 14/01	327	8.6	-4.3	-11.1	-0.6	-18.0	8.6	7.4	-0.5	2.0	-1.0	-0.5	-0.5	-30.3	43.1	-0.6	57.2	-1.3	30.5	81.6	13953.6	8596.8	0.0	3936.0	4660.8	32.1	1809.6	938.4	4936.8	12377.8	88.7
AVERAGE	Batch 11/23		9.6	-4.2	-12.5	-0.3	-16.9	9.8	7.3	-0.6	1.7	-0.2	-0.4	-1.3	-30.3	43.2	1.8	55.6	1.4	30.5	82.7	15201.9	8291.6	0.0	4117.4	4174.2	34.4	1806.5	1137.1	4772.6	11926.8	78.5
Batch 12/24	Sat 15/01	328																														
	Sun 16/01	329																														
	Mon 17/01	330	17.1	-15.9	-8.5	-1.8	-26.2	17.1	9.2	-0.4	1.8	-0.8	-0.4	-0.6	-23.0	34.7	-0.3	48.9	-0.7	23.1	70.2	11268.9	7332.0	0.0	3175.9	4156.1	26.7	1377.8	246.7	4153.1	9960.4	88.4
	Tues 18/01	331																														
	Wed 19/01	332	9.8	-2.4	-25.6	5.5	-28.1	15.3	12.8	-0.0	-5.1	2.2	7.3	-0.2	-34.3	46.8	-0.3	88.6	7.0	39.7	89.8	15298.8	12830.4	649.8	4274.4	7906.2	178.7	1991.1	1192.5	4399.8	15666.3	102.4
	Thur 20/01	333	15.8	-9.2	-18.3	-3.1	-30.5	15.8	15.0	0.2	-0.7	1.2	-0.4	-0.0	-32.1	41.4	3.1	75.8	2.6	32.6	88.8	14556.5	9156.4	84.2	4060.9	5013.3	40.3	1837.2	781.3	4317.6	11989.7	82.4
	Frid 21/01	334	10.1	-2.1	-17.1	-3.1	-22.3	10.1	12.2	-0.2	0.9	0.2	-0.6	-0.4	-31.8	44.3	-0.3	66.9	-1.1	32.8	78.3	13158.4	9600.0	14.6	4047.7	5537.5	35.0	1882.1	904.8	4317.6	12658.6	96.2
	Sat 22/01	335																														
	Sun 23/01	336	13.1	-4.0	-17.1	-1.8	-22.9	13.1	9.8	-0.7	3.3	-1.3	-1.1	-0.8	-36.6	53.6	0.9	75.7	-0.2	37.0	77.4	16283.5	7312.8	0.0	4984.7	2328.1	61.4	2253.6	966.9	4194.2	9824.2	60.3
	Mon 24/01	337	12.6	-3.3	-18.0	0.0	-21.3	12.6	8.7	-0.3	1.6	-1.1	0.3	-0.6	-33.1	42.7	5.3	67.0	5.6	32.4	78.2	14393.3	7562.4	21.0	4392.4	3149.0	11.2	1926.7	868.8	4384.2	10339.6	71.8
	Tues 25/01	338	14.7	-5.4	-19.2	0.0	-24.6	14.7	9.9	0.0	0.6	-0.2	-0.3	-0.8	-35.1	46.4	3.5	68.5	3.2	35.1	79.4	15055.0	8054.4	0.0	4561.2	3493.2	8.7	2042.7	827.2	4715.0	11086.8	73.6
	Wed 26/01	339	18.6	-23.1	-3.6	-2.4	-29.2	18.6	10.5	-0.6	2.9	-1.9	-0.3	-0.9	-39.1	53.4	2.0	69.7	1.7	37.7	82.8	14972.3	7564.8	0.0	5059.9	2504.9	28.6	2286.5	1034.0	4839.1	10693.1	71.4
	Thur 27/01	340	15.3	-6.8	-15.6	-0.6	-22.8	15.3	7.5	-0.7	2.9	-1.5	-0.8	-0.8	-37.6	52.2	0.4	65.5	-0.2	36.2	84.3	14806.9	6734.4	0.0	4804.7	1929.7	41.6	2181.6	827.2	4715.0	9705.4	65.6
	Frid 28/01	341																														
AVERAGE	Batch 12/24		14.1	-8.0	-15.9	-0.6	-24.7	14.1	10.6	-0.3	0.9	-0.4	0.4	-0.6	-33.9	48.2	1.6	67.2	2.0	33.8	79.1	14421.0	8461.1	29.0	4364.8	4067.2	10.3	1968.9	852.1	4448.4	11347.0	78.7
Batch 13/25	Sat 29/01	342																														
	Sun 30/01	343	12.9	-4.8	-12.0	-1.2	-18.0	12.9	5.1	0.0	0.0	0.0	0.1	-0.1	-16.8	21.9	1.3	23.4	1.4	16.8	101.2	10588.2	6172.8	5.6	2124.1	4043.1	0.0	984.8	744.5	4880.5	10632.8	100.4
	Mon 31/01	344	13.5	-5.1	-15.8	-1.2	-21.9	13.5	8.4	-0.0	-0.0	0.1	0.0	-0.0	-20.0	28.3	-1.9	34.4	-1.9	22.0	90.2	13152.5	5592.0	9.8	2589.1	2993.1	1.4	1255.6	744.5	5128.6	10123.2	77.0
	Tues 01/02	345	12.8	-6.1	-18.3	-1.8	-26.3	12.8	13.5	-0.0	-0.4	0.5	0.1	0.1	-23.8	31.8	-0.4	45.0	-0.3	24.5	82.2	15965.0	6660.0	40.5	2915.8	3703.6	13.2	1388.2	785.8	4880.5	10769.4	87.8
	Wed 02/02	346								0.0	-0.4	0.4	0.1	0.2	-22.3	28.9	1.0	41.2	1.0	22.7	83.6	13879.7	6312.0	31.5	2731.6	3548.9	12.4	1278.2	661.6	5004.6	10505.6	75.2
	Thur 03/02	347																														
	Frid 04/02	348																														
	Sat 05/02	349	15.0	-2.4	-20.8	1.8	-23.2	16.8	6.4	-0.0	-0.2	0.5	-0.1	-0.1	-20.3	26.8	1.1	40.4	1.0	20.8	80.7	14198.4	6336.0	35.0	2549.3	3751.7	12.2	1185.3	897.6	4936.8	10783.7	78.6
	Sun 06/02	350	13.1	-2.1	-22.0	0.8	-24.2	13.6	10.4	-0.0	-0.2	0.4	-0.1	-0.2	-21.8	28.2	1.9	43.2	1.9	22.0	80.9	14280.0	9189.6	28.8	2749.1	6414.0	8.9	1245.0	734.4	4977.6	13379.9	93.7
	Mon 07/02	351	15.9	-2.1	-26.9	-3.1	-32.1	15.9	16.2	-0.0	-0.3	0.4	0.0	-0.0	-28.8	40.2	-2.5	40.4	-2.5	31.4	102.2	15177.8	7939.2	30.8	3676.8	4231.7	9.4	1781.8	1224.0	5283.2	12510.1	82.4
	Tues 08/02	352	16.5	-3.7	-24.5	0.0	-28.2	16.5	11.6	-0.0	-0.1	0.3	-0.2	0.1	-25.5	32.7	2.1	39.7	2.0	25.6	83.6	13484.0	7735.2	23.1	3181.2	4530.9	8.8	1480.3	693.6	5100.0	11783.7	87.6
	Wed 09/02	353	16.2	-4.0	-23.3	-1.2	-28.5	16.2	12.2	-0.0	-0.5	1.2	-0.5	-0.2	-28.5	35.3	1.1	34.7	0.5	27.2	106.4	14467.8	8992.8	82.3	3320.0	5560.5	36.8	1525.4	1137.9	5060.0	13370.5	92.4
	Thur 10/02	354	16.5	-5.5	-26.9	1.2	-32.4	17.8	14.7	-0.0	-0.1	0.3	0.0	-0.1	-27.9	37.6	-0.2	41.2	-0.2	26.4	96.5	13655.0	7747.2	20.0	3452.9	4274.3	5.6	1613.7	772.2	4958.1	11623.8	85.1
	Frid 11/02	355																														
AVERAGE	Batch 13/25		14.7	-4.0	-21.2	-0.5	-25.7	14.7	11.6	-0.0	-0.2	0.4	-0.1	-0.1	-23.2	31.1	0.3	38.3	0.3	23.5	90.1	13892.8	7267.7	27.0	2874.8	4365.9	9.0	1331.8	838.6	5021.0	11568.9	83.3
Batch 14/26	Sat 12/02	356																														
	Sun 13/02	357																														

Batch	Date	Day	delta P An	delta P Ax	delta P Aero	delta P SST	P uptake	P release	P removal	delta NH3 An	delta NH3 Ax	delta NH3 Aero	delta NH3 ST	delta NO3 An	delta NO3 Ax	delta NO3 Aero	delta NO3 ST	Nitri cap. No	delta N SST	N2 produc	TKN balance	COD in	OUR T	NO for NO3 nitr	NO for NH3 nitr	NOc	NO2 Denit	NO3 Denit	COD eff	COD waste	COD out	COD balance
			mgP/l influent							mgN/l				mgN/l				mgN/l	mgN/l	mgN/l		mgCOD/d	mgO/d	mgO/d	mgO/d	mgO/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	
	Mon 14/02	358	16.2	-2.4	-23.2	-3.1	-28.7	16.2	12.5	-0.7	1.8	-0.3	-0.2	-3.8	-31.6	47.6	8.1	58.9	7.8	34.3	97.3	12354.8	8414.4	0.0	5087.5	3326.9	32.0	2026.8	1097.3	5161.3	11648.0	94.3
	Tues 15/02	359	15.9	0.3	-25.8	-2.4	-28.1	16.2	11.9	-0.7	1.3	0.6	-0.3	-4.1	-29.9	49.2	2.8	63.8	2.5	33.4	88.1	12923.5	7070.4	38.4	4759.8	2272.2	37.0	1945.0	1137.9	4511.0	9903.2	78.6
	Wed 16/02	360	17.1	-5.2	-20.8	0.9	-25.9	17.1	8.9	-0.5	1.3	0.4	-0.7	-3.0	-34.3	49.3	7.5	60.3	6.8	38.5	97.2	12435.8	7730.4	26.1	5186.0	2518.3	43.5	2131.5	731.5	4185.9	9810.7	77.3
	Thur 17/02	361	18.2	-4.6	-22.0	-0.6	-27.2	18.2	11.0	-0.5	-0.1	2.5	-1.5	-3.3	-31.8	47.5	5.9	78.9	4.4	35.7	76.7	17203.2	9206.4	166.4	4884.2	4153.8	68.8	2008.8	983.0	4484.8	11678.9	67.9
	Frid 18/02	362																														
	Sat 19/02	363																														
	Sun 20/02	364	22.6	-4.6	-26.9	-0.8	-32.0	22.6	9.5	-0.3	-0.5	2.2	-1.0	-1.9	-34.1	49.9	1.0	69.7	0.0	36.6	81.7	14008.3	9072.0	149.2	4657.5	4285.4	59.0	2055.1	737.3	4300.8	11417.6	81.5
	Mon 21/02	365	14.8	-2.4	-26.5	-3.6	-32.6	14.8	17.8	-0.3	0.3	1.1	-0.9	-0.5	-12.7	11.9	33.3	71.1	3.7	41.8	88.1	14909.4	7968.0	78.6	4131.3	3758.1	40.7	753.3	860.2	4505.6	9917.8	66.5
	Tues 22/02	366	18.1	-1.5	-26.5	-0.8	-28.8	18.1	10.6	-0.0	-0.8	1.7	-0.7	-0.4	-41.8	55.5	2.1	52.8	1.3	43.1	110.0	13434.9	7948.8	118.8	5264.8	2565.2	54.0	2414.1	880.2	4628.5	10522.0	78.3
	Wed 23/02	367	18.6	-2.1	-28.9	-4.2	-36.3	18.6	18.7	-0.3	0.1	0.9	-0.5	-0.4	-40.0	54.0	1.0	64.0	0.5	40.5	91.6	14581.8	6448.8	63.6	5024.2	1361.0	25.7	2310.5	1024.0	4856.2	9677.3	66.4
	Thur 24/02	368																														
	Frid 25/02	369																														
AVERAGE	*Batch 14/26*		*17.2*	*-2.8*	*-25.1*	*-1.8*	*-29.6*	*17.2*	*12.6*	*-0.4*	*0.4*	*1.1*	*-0.7*	*-2.2*	*-35.6*	*50.9*	*4.1*	*64.9*	*3.4*	*37.7*	*90.6*	*13981.4*	*7982.4*	*77.9*	*5024.5*	*2880.0*	*39.3*	*2160.8*	*926.9*	*4589.2*	*10598.2*	*75.8*
Batch 15/27	Sat 26/02	370																														
	Sun 27/02	371	21.4	-6.3	-27.7	1.2	-34.1	22.8	11.5	0.1	-0.1	0.2	-0.1	-0.1	-31.3	42.3	-0.0	45.6	-0.2	31.6	98.9	13516.8	8460.8	13.4	3863.7	2563.7	7.9	1799.8	901.1	5570.8	10863.1	80.4
	Mon 28/02	372	26.3	-11.2	-30.2	0.7	-41.4	26.9	14.5	-0.0	-0.4	1.1	-0.6	-1.8	-26.2	39.9	-0.1	54.3	-0.7	28.9	83.3	13516.8	7027.2	76.6	3649.6	3300.9	34.0	1598.9	1269.8	5611.5	11815.1	87.4
	Tues 29/02	373	27.6	-8.9	-32.8	-2.8	-44.4	27.6	16.8	-0.0	0.2	-0.0	0.0	-1.9	-36.3	55.1	-2.0	58.7	-2.0	40.0	97.6	14499.6	5673.6	0.0	5034.3	839.3	0.8	2297.1	1228.8	5939.2	10105.2	69.7
	Wed 01/03	374	26.3	-10.5	-27.6	-3.3	-41.4	26.3	15.1	-0.2	0.1	1.0	-0.6	-4.3	-32.8	58.0	-0.0	57.8	-0.7	38.0	101.4	12533.8	5848.8	68.4	5120.6	661.8	29.1	2133.7	737.3	4997.1	8558.9	68.3
	Thur 02/03	375	25.3	-10.5	-23.7	-3.9	-38.1	25.3	12.6	-0.4	1.2	0.0	-0.6	-5.7	-32.8	56.9	3.8	64.1	2.9	37.6	97.6	14166.3	5787.2	2.6	5524.0	240.6	34.5	2199.1	1062.0	5182.8	8718.7	61.5
	Frid 03/03	376																														
	Sat 04/03	377																														
	Sun 05/03	378																														
	Mon 06/03	379	27.3	-13.1	-32.8	2.0	-46.0	28.2	16.8	-0.2	0.9	-0.8	0.0	-0.8	-38.6	52.1	2.4	69.2	2.4	38.7	85.1	13338.7	6684.0	0.0	4987.6	1696.2	7.6	2252.2	892.1	5352.5	10200.8	76.6
	Tues 07/03	380	28.5	-9.5	-30.8	-3.7	-43.8	28.5	15.3	-0.3	0.6	0.2	-0.4	-2.8	-37.1	55.3	2.8	62.3	2.4	39.5	98.9	15037.9	7591.2	14.0	5316.8	2260.8	21.8	2282.3	1359.4	6074.8	11998.7	79.8
	Wed 08/03	381	30.0	-4.0	-39.2	-1.8	-45.0	30.0	15.0	-0.6	2.7	-1.8	-0.1	-2.8	-37.4	50.8	10.2	70.4	10.1	38.1	89.2	12998.9	7423.2	0.0	5575.3	1847.9	24.4	2301.1	1104.5	5522.4	10800.3	83.1
	Thur 09/03	382	25.1	-7.0	-29.4	-1.8	-38.3	25.1	13.2	-0.7	3.0	-2.2	0.0	-1.7	-37.8	54.1	5.2	83.3	5.2	37.1	94.8	14199.6	7216.8	0.0	5421.2	1795.8	22.7	2258.1	1149.1	5704.6	10930.1	77.0
AVERAGE	*Batch 15/27*		*26.4*	*-9.0*	*-30.6*	*-1.5*	*-40.9*	*26.4*	*14.6*	*-0.3*	*0.9*	*-0.2*	*-0.3*	*-2.4*	*-34.5*	*51.4*	*2.8*	*60.8*	*2.2*	*36.2*	*93.1*	*13759.0*	*6832.5*	*0.0*	*4922.0*	*1710.5*	*18.0*	*2111.1*	*1078.2*	*5550.8*	*10488.5*	*76.1*
Batch 16/28	Frid 10/03	383																														
	Sat 11/03	384																														
	Sun 12/03	385	17.1	-6.4	-22.0	-0.6	-29.1	17.1	11.8	-0.8	4.1	-3.0	-0.1	-3.3	-31.5	50.8	0.8	65.1	0.7	31.5	82.8	14384.0	6991.2	0.0	4698.0	2293.2	33.4	1891.2	1149.1	5991.8	11458.7	78.8
	Mon 13/03	386																														
	Tues 14/03	387	29.0	-5.6	-33.3	-3.1	-42.0	29.0	13.0	-0.2	0.3	-0.2	0.8	-0.3	-29.2	40.8	-1.1	59.3	-0.3	29.9	79.4	14610.2	6237.6	52.5	3730.5	2454.6	8.5	1753.5	1190.2	5991.8	11398.6	78.0
	Wed 15/03	388	29.0	-3.7	-38.3	0.6	-42.0	29.8	12.3	-0.2	0.4	-0.5	1.0	-0.4	-42.1	60.4	-4.5	61.5	-3.5	45.9	100.0	14856.5	6674.4	67.2	5520.3	1088.9	8.2	2688.2	902.9	5171.0	8657.2	84.3
	Thur 16/03	389	18.8	32.1	-53.1	-13.0	-86.0	50.9	15.1	0.0	-2.4	4.4	-1.6	0.1	-24.4	19.0	20.3	62.6	18.8	29.8	77.3	13379.0	8475.2	301.5	3588.2	2585.5	139.2	1395.0	615.6	5540.4	10275.7	78.8
	Frid 17/03	390																														
	Sat 18/03	391																														
	Sun 19/03	392	31.2	-4.0	-38.3	-1.2	-43.5	31.2	12.3	-0.4	-0.4	2.8	-1.8	-0.1	-45.9	58.4	5.0	68.4	3.2	46.8	99.6	13465.9	7070.4	198.5	5794.1	1077.8	91.5	2633.7	730.1	5353.9	9887.0	73.4
	Mon 20/03	393	32.7	-8.6	-35.8	-1.9	-46.3	32.7	13.6	-0.4	1.8	-1.2	-0.2	-1.4	-44.6	65.3	-2.3	64.5	-2.4	47.0	101.6	14358.2	6763.2	0.0	5969.0	794.2	18.0	2760.0	1500.7	6449.0	11522.0	80.2
	Tues 21/03	394	39.0	-7.8	-48.1	0.7	-53.9	39.6	14.2	-0.5	2.3	-1.8	0.1	-1.5	-47.9	70.0	-1.8	66.4	-1.7	49.3	104.2	15483.9	6835.2	3.8	6397.2	434.2	15.7	2928.0	1095.1	5597.3	10070.3	65.0
	Wed 22/03	395	35.6	-3.0	-48.1	-0.7	-49.8	35.6	14.2	-0.4	1.8	-1.5	0.1	-3.2	-43.1	68.5	-0.1	67.8	0.0	44.8	99.2	14063.0	6638.4	7.8	6079.2	611.8	14.4	2653.7	1274.7	5510.1	10064.6	71.6
	Thur 23/03	396																														
AVERAGE	*Batch 16/28*		*29.0*	*-0.9*	*-39.1*	*-2.4*	*-42.4*	*29.0*	*13.3*	*-0.4*	*1.0*	*-0.1*	*-0.2*	*-1.3*	*-38.8*	*53.9*	*2.0*	*64.2*	*1.8*	*39.2*	*92.0*	*14323.9*	*6718.2*	*0.0*	*5110.1*	*1808.1*	*20.7*	*2279.7*	*1057.3*	*5700.7*	*10666.5*	*74.6*
Batch 17/29	Frid 24/03	397																														
	Sat 25/03	398																														
	Sun 26/03	399	32.2	-0.9	-44.6	3.1	-45.8	35.3	10.2	0.0	-0.3	0.6	-0.2	0.2	-14.3	17.5	2.1	18.9	1.8	14.6	104.2	13569.6	6254.4	39.3	1791.6	4423.5	18.2	819.3	1069.1	5592.3	11922.5	87.9
	Mon 27/03	400																														
	Tues 28/03	401	34.1	-7.4	-40.9	0.8	-48.3	34.7	13.8	0.0	-0.0	0.3	-0.2	0.2	-23.9	31.4	0.5	45.8	0.3	23.9	81.1	13454.0	6458.4	18.8	2923.3	3516.3	8.0	1367.1	897.6	5140.8	10929.8	81.2
	Wed 29/03	402	35.9	-1.9	-54.5	2.5	-56.4	38.4	16.0	0.3	-1.8	2.8	-1.4	0.2	-23.7	30.8	1.1	50.2	-0.3	25.7	78.1	15993.6	6237.6	190.0	2920.6	3127.0	104.1	1356.0	1060.6	6201.6	11851.5	74.1
	Thur 30/03	403	38.3	-3.4	-47.1	-4.3	-54.9	38.3	16.6	0.0	-0.7	1.8	-0.8	-0.3	-28.1	36.7	-1.7	54.2	-2.5	28.5	80.9	16075.2	6494.4	108.4	3357.9	3028.1	52.1	1602.2	1468.8	5712.0	11863.2	73.8
	Frid 31/03	404																														
	Sat 01/04	405																														
	Sun 02/04	406	55.2	-33.8	-34.7	-5.8	-74.1	55.2	18.9	-0.0	-0.3	0.4	0.2	0.3	-28.2	38.5	0.1	55.8	0.3	28.5	79.7	15687.2	5894.4	44.0	3528.2	2322.2	12.1	1670.7	1224.0	4896.0	10125.1	64.8
	Mon 03/04	407	39.4	-3.7	-58.3	1.9	-62.0	41.2	20.8	0.3	-0.8	0.0	0.6	0.1	-27.5	36.4	0.4	64.3	0.9	28.0	92.0	15096.0	6794.4	39.3	3357.0	3398.2	19.8	1570.6	1080.6	5875.2	11924.3	79.0
AVERAGE	*Batch 17/29*		*38.8*	*-8.5*	*-46.7*	*-0.3*	*-55.5*	*38.8*	*16.7*	*0.1*	*-0.8*	*0.9*	*-0.3*	*0.1*	*-24.1*	*31.9*	*0.4*	*44.6*	*0.1*	*24.7*	*84.0*	*14977.8*	*6355.6*	*64.1*	*2954.4*	*3337.1*	*31.0*	*1379.7*	*1130.2*	*5569.7*	*11447.6*	*76.4*
Batch 18/30	Tues 04/04	408																														
	Wed 05/04	409	40.8	-4.6	-56.9	-0.8	-62.2	40.8	21.3	-0.1	0.4	-0.0	-0.2	-0.4	-27.8	37.5	1.7	44.6	1.8	27.9	93.3	15564.8	7370.4	0.0	3583.4	3787.0	10.1	1612.0	1228.8	5775.4	12413.3	79.8
	Thur 06/04	410	38.0	-6.2	-56.9	-1.2	-64.3	38.0	26.3	0.0	-0.1	0.2	0.1	-0.5	-26.8	36.1	0.9	46.7	1.0	27.2	87.1	15646.7	6993.6	15.0	3382.1	3596.5	4.3	1551.0	1433.6	5896.2	12483.7	79.8
	Frid 07/04	411	40.8	-0.3	-54.4	-5.6	-60.3	40.8	19.5	0.0	-0.2	0.3	0.1	-0.3	-27.0	35.9	1.4	46.2	1.5	27.5	88.8	17530.9	5642.4	23.7	3412.4	2206.2	7.2	1562.3	1065.0	5447.7	10288.4	58.7
	Sat 08/04	412	37.4	-0.6	-53.2	-3.1	-58.9	37.4	19.5	0.1	-0.1	-0.0	0.1	-0.2	-27.5	36.2	2.3	48.7	2.5	27.7	85.9	14909.4	6597.6	7.9	3518.5	3071.2	2.9	1584.0	1065.0	5406.7	11129.7	74.6
	Sun 09/04	413	42.1	-10.2	-48.2	0.0	-58.5	42.1	18.4	0.0	-0.2	0.3	0.0	-0.2	-26.9	36.0	0.7	45.2	0.7	27.3	88.0	16056.3	6244.8	20.6	3350.7	2873.5	7.1	1550.2	1024.0	5570.8	11025.3	68.7
	Mon 10/04	414	43.3	-2.5	-49.5	-7.4	-59.4	43.3	18.1	-0.0	-0.3	0.5	-0.0	-0.3	-26.7	35.5	1.3	43.8	1.3	27.3	90.5	17121.3	7188.0	33.2	3363.4	3791.3	11.1	1541.8	660.2	5079.0	11283.5	65.9
	Tues 11/04	415	33.9	1.8	-53.6	1.8	-53.8	37.5	18.1	-0.0	-1.1	0.1	2.2	-0.5	-25.4	36.0	-0.9	48.2	1.3	27.0	88.0	13762.6	7214.4	155.2	3292.6	3766.5	37.4	1533.8	778.2	5038.1	11154.1	81.0
	Wed 12/04	416	14.0	-3.0	-26.2	-2.4	-31.5	14.0	17.6	-0.1	0.3	-0.1	0.0	-1.2	-24.2	34.5	1.8	41.7	1.6	25.2	92.9	19415.0	7053.6	0.0	3306.9	3746.7	2.8	1455.1	1187.6	6021.1	12413.6	63.9
	Thur 13/04	417	19.8	0.6	-33.3	-1.2	-34.5	20.2	14.2	-0.1	0.1	0.0	0.1	-0.0	-30.7	41.5	-0.5	47.9	-0.4	31.1	92.5	14581.8	7034.4	8.9	3794.3	3231.2	2.0	1787.5	1515.5	5161.0	11697.2	80.2
	Frid 14/04	418	41.7	-10.1	-50.0	1.2	-60.1	42.9	17.3	0.1	-0.1	0.1	0.1	0.2	-28.3	36.3	2.2	45.7	2.3	28.5	91.2	14909.4	7224.0	16.1	3518.9	3691.0	4.9	1620.5	1351.7	5528.6	12197.6	81.8
	Sat 15/04	419																														
	Sun 16/04	420	36.3	-10.1	-39.3	-4.2	-53.6	36.3	17.3	-0.3	1.6	-1.1	-0.1	-0.9	-22.7	36.9	-6.0	62.5	-6.0	26.4	70.6	16875.5	5923.2	0.0	3371.9	2531.3	13.3	1693.0	942.1	5775.4	10975.1	65.0
	Mon 17/04	421	35.7	-6.6	-46.4	-1.2	-54.5	35.7	18.7	-0.5	2.8	-2.3	0.1	-0.6	-28.1	39.0	1.1	48.6	1.2	28.6	87.2	15401.0	6235.2	8.9	3687.9	2558.4	18.7	1651.1	1065.0	5570.6	10863.7	70.6

	Date	Day	delta P				P	P	P	delta NO2				delta NO3				Nitri cap.	delta N	N2	TKN		OUR T	NO for	NO for		NO2	NO3	COD	COD	COD	COD
			An	Ax	Aero	SET	uptake	release	removal	An	Ax	Aero	ST	An	Ax	Aero	ST	Ae	SET	produc.	balance	COD in		NO2 nitr	NO3 nitr	MOc	Denit	Denit	eff	waste	out	balance
			mgP/l balance							mgN/l				mgN/l				mgN/l	mgN/l	mgN/d		mgCOD/d	mgO/d	mgO/d	mgO/d	mgO/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	mgCOD/d	
AVERAGE	Batch 18/30		35.3	-4.3	-47.3	-2.0	-53.7	35.3	18.4	-0.1	0.3	-0.2	0.2	-0.4	-36.8	38.6	0.5	47.4	0.7	27.1	88.5	15981.2	6728.8	14.7	3407.1	3305.0	2.9	1559.1	1128.4	5322.8	11516.2	72.1